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FIVE NEW SPECIES OF *PAUCIVENA* DAVIS, 1975 (LEPIDOPTERA: TINEOIDEA: PSYCHIDAE) FROM CUBA

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ABSTRACT. Five new species of *Paucivena* Davis (Lepidotera: Tineoidea: Psychidae), *P. ferruginea*, *P. pinarensis*, *P. fusca*, *P. cubana* and *P. orientalis* are described from Cuba and compared with relatives. The females of *P. ferruginea* and *P. orientalis* are described being the first females known within genus; their characteristics confirm the intermediate position of the genus among the American psychids. Notes on natural history of new species (e.g. hosts, habitat) are given as available. Keys for identification of known stages of all *Paucivena* species are provided.

Additional key words: Tineoidea, Psychidae, bagworm, natural history, West Indies.

The Neotropical region has the richest Lepidoptera diversity but one of the least studied psychid fauna with only 61 known species (Heppner, 1998; Davis, 2000). This species number is extremely low compared with that of other faunal regions. The Paleartic, for example, has more than 300 described species (Heppner, 1998). Members of this family were last reviewed by Davis (1975) who described two genera and five species from the West Indies. However, none of these taxa was known from Cuba. Recent collections from Cuba, chiefly on the three main mountain chains, have resulted in the discovery of new records including several new species. In this work, five new species belonging to *Paucivena* Davis, 1975 are described. Keys for identification of known stages of all species and information on natural history are also provided.

MATERIALS AND METHODS

Individuals of all species, except one whose representatives were taken flying at day, were collected as larvae and pupae in the field and reared in the laboratory. Lab-reared larvae were provided with field collected hosts until pupation. All type material is deposited at Instituto de Ecología y Sistemática (CZACC).

Diagnostic morphological characters employed follows Davis (1964, 1975) and Henderickx (1982). Setal maps of larvae follow Hinton (1946) and Stehr (1987). Measurements were taken with an ocular micrometer in a Carl Zeiss Stemi 2000 stereoscopic microscope. Interocular index of head was calculated as a ratio between the vertical diameter of the compound eye and interocular distance measured at a point across the frons midway between the base of antennal sockets and the anterior tentorial pits (Davis, 1975):

Interocular index= vertical eye diameter/ interocular distance

Characters of the two previously known species, *Paucivena reticulata* Davis, 1975 and *Paucivena hispaniolae* Davis, 1975, were taken from original descriptions and illustrations. Additionally, one *P. reticulata* specimen placed at CZACC, was examined.

Abbreviations: $\bar{x}$- mean, SD- standard deviation, CV- coefficient of variation.

RESULTS

Paucivena Davis, 1975

This genus is known only from the western part of the Antilles. Davis (1975) described *P. hispaniolae* from Dominican Republic, Hispaniola, and *P. reticulata* from Puerto Rico and Jamaica. In the same work, this author mentioned the possible presence of *Paucivena* on Cuba. This was confirmed recently by Núñez (2004) based on unknown species from Topes de Collantes, in the Cuban central mountains, which are described here.

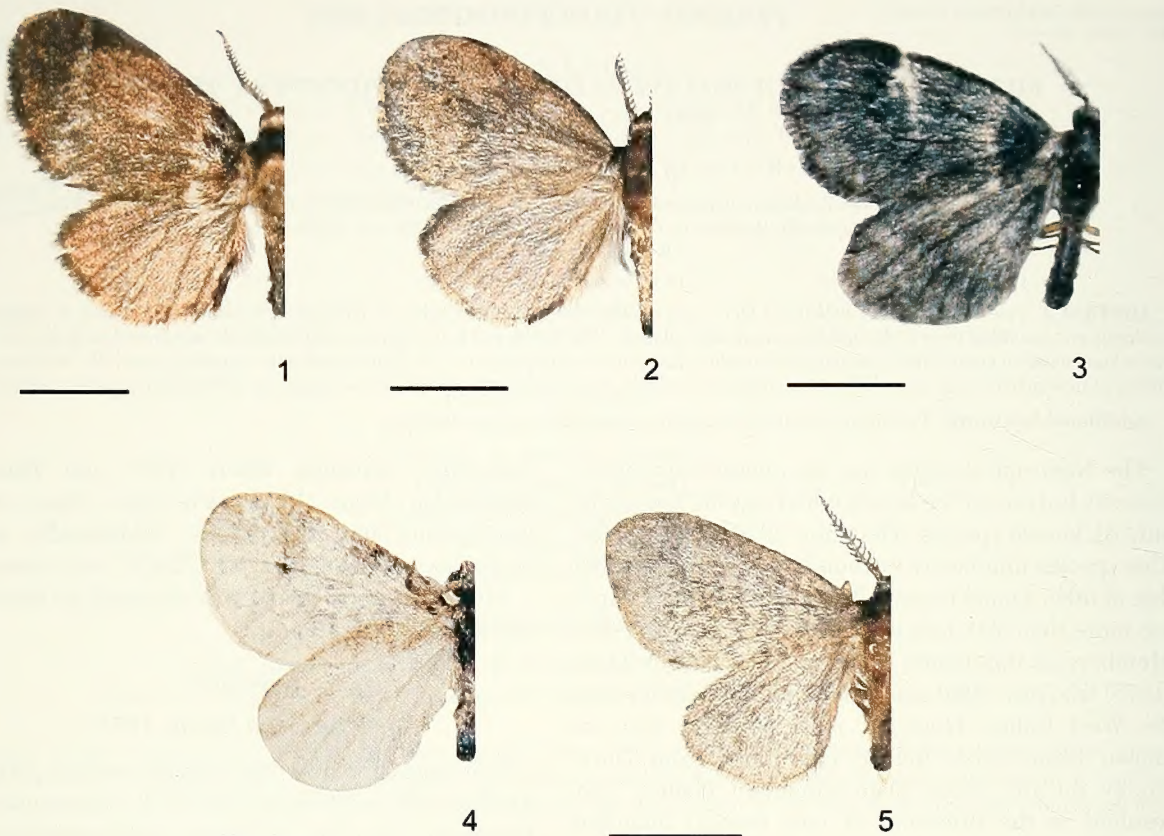
Characters that best define *Paucivena* males are labial palpi with a single segment not fused, origin of antennal rami at base of each antennal segment, two pairs of tibial spurs on mid and hindlegs, reduced wing venation and the abbreviated genitalia. Females may be recognized by the possession of compound eyes and functional legs, and the lack of antennae and wings. Larvae feed on several hosts including mosses and lichens growing on rocks and bark, and detritus.

Paucivena ferruginea Núñez, new species

(Figs. 1, 6, 11, 16, 17, 22, 24, 26, 28–35, 41, 45–46, 52)

Diagnosis: *Paucivena ferruginea* male differs from all other *Paucivena* by its brown coloration with slight ferruginous iridescence. Other diagnostics characters are the acute and heavily sclerotized sacculus and the bifid saccus of its genitalia.

Male (Figs. 1, 6, 11, 16, 17). *Head*: brown. Antennae with 23 segments; lateral pectinations about 2–2.5 times length of supporting segment. Vertical diameter of eye 0.8 the interocular distance. *Thorax* (Figs. 6, 11): anterior half dark brown, posterior half brown with slight ferruginous iridescence; underside pale brown except inner surface of



FIGS. 1–5. *Paucivena* spp. adult males. **1** *P. ferruginea*, n. sp.; **2** *P. pinarensis*, n. sp.; **3** *P. fusca*, n. sp.; **4** *P. cubana*, n. sp.; **5** *P. orientalis*, n. sp. Scale= 3 mm.

coxa and femur of forelegs which are dark brown. Vestiture dense, scales hairlike. Wings brown with slight ferruginous iridescence; basal two thirds of costa on FW dark brown. Tibial spurs approximately 0.35 the length of basal tarsal segments (Fig. 6). Scales at discal cell variable in shape: oblanceolated, ovobated, with rounded or acute apices, or hairlike. FW with 9 veins, all veins separated (Fig. 11); accessory cell present; CuP not reaching inner margin; one anal vein. HW with 7 veins, all veins separated except M_{2+3} and CuA_1 which have a unique origin; cross vein between Sc and Rs absent; two anal veins. Wing expanse: 11 mm. *Abdomen*: brown with slight ferruginous iridescence; underside pale brown. Vestiture dense, scales hairlike. *Genitalia* (Figs. 16–17): tegumen broad, with a pair of sparsely setose apical lobes. Valvae with pulvilli setose; apex of sacculus acute and heavily sclerotized, armed with three spines; cucullus apically rounded and sparsely setose. Saccus bifid, apices blunt; approximately 0.1 the length of main body. Aedeagus simple, cylindrical, 0.7 times the length of valvae.

Female (Figs. 22, 24, 26). Length: 7.5 mm. Vermiform. Stramineous, with two longitudinal bands of brown spots on dorsum. *Head* (Fig. 22): stramineous, eyes black. Slightly sclerotized. Shape near ovoid (ventral view); eyes compound, well developed, subventral. Labial palpi 1-segmented, 100% fused; antennae absent. *Thorax* (Fig. 24): patterned as above; body wall slightly sclerotized. Legs functional, armed with numerous tiny spines; tarsi 1-segmented with a pair of claws at distal end (Fig. 24); wings absent. *Abdomen*: color pattern disappearing at A2–A3; membranous and naked except for a ring of dense brownish ochre hairlike scales around A7. External genitalia reduced (Fig. 26), largely membranous. Two pairs of apophyses present; anterior pair elongated, free except bifid base fused with tegument; posterior pair straight and free.

Larva (Figs. 28–34). Length of largest larva 11 mm, maximum width of head capsule 1.2 mm. Head and thorax whitish with dark fuscous longitudinal bands continued on thorax forming a striated pattern; spiracle on TI as large as spiracle on A8, both larger than spiracles on A1–A7. *Head* (Figs. 28–32): patterned as above, lateral area with five elongated bands; labrum ochre; an elongated band on adfrontal sclerite and frons extending from C1 to slightly beyond AF1; AF2 and P2 absent (Fig. 28). Six stemmata present; five arranged in an inverted semicircle, a sixth more distant and ventrad, immediately anterior to S3 (Fig. 29). Labrum (Figs. 30, 31) with LA3 isolated. Mandibles with four acute teeth and a fifth, blunt tooth (Fig. 32). *Thorax* (Fig. 33): patterned as above, three longitudinal bands between body axis and lateral margin of shield, interrupted on metathorax. TI with shield bearing D, SD, XD and L groups; XD-group and L2 in vertical line near anterior margin of shield, SD-group slightly posterior; XD1 about equal in length to SD1, about 2 times longer than XD2 and D2; D1 dorsoposterior to XD1, about 1/4 its length; SD2 above SD1, slightly posterior and about 1/4 its length; L-group trisetose, L1 about 3 times longer than L2 and L3, posteroventral to L2; L3 slightly longer than L2; spiracle dorsoposterior to L-group, diagonal; SV-group in horizontal line on elongated pinnaculum, SV2 about 3/5 length of SV1; MV2 on same pinnaculum, anterior to SV2; V1 about equal in length to SV2, posteroventral to SV1. TII-TIII: D and SD groups in a vertical line on same pinnaculum; D2 about 2–21/2 times longer than D1; SD1 about 3 times longer than SD2; L2 separated from pinnaculum bearing L1 and L3, about 1/2 length of L3; L1 3/5 length of L2, dorsoposterior to L3; SV group on same pinnaculum; SV1 about twice length of SV2; V1 slightly shorter than SV1. *Abdomen* (Figs. 33, 34): integument dark brown, pinnacula brownish ochre. A1: D-group on separated pinnacula, D1 dorsoposterior to D2 and about 3 1/2 times longer; SD1 above and slightly anterior to spiracle, slightly shorter than D2; SD2 minute, anterodorsal to spiracle; L-group trisetose, on separated pinnacula; L1 posterior to L2 and about twice its length; L3 below,

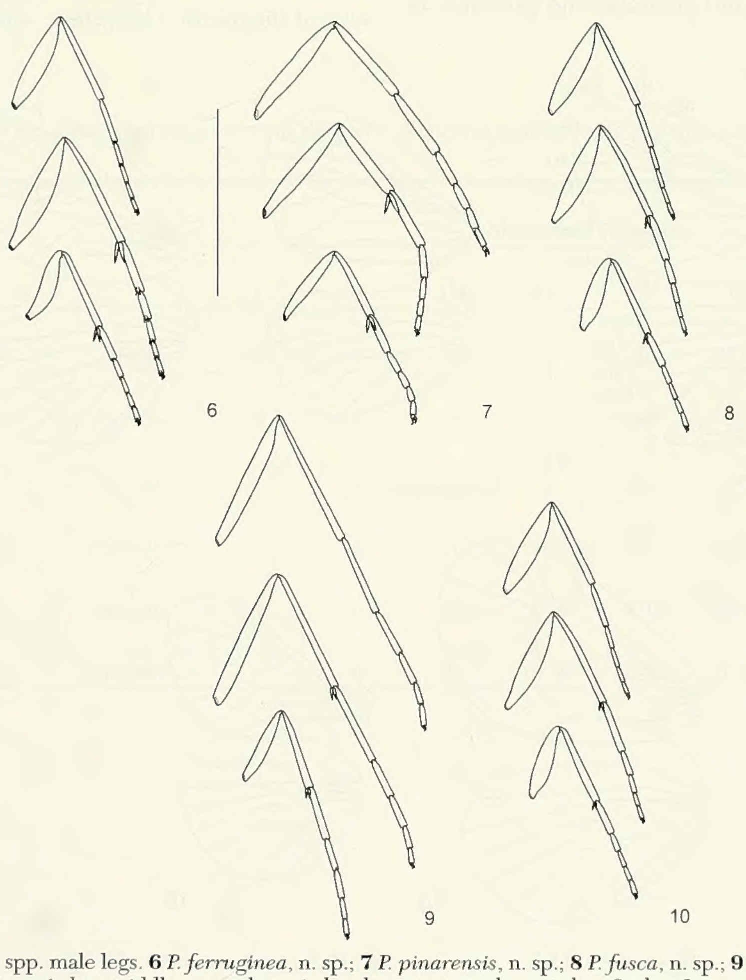
midway between L1 and L2, equal in length to L1; SV-group bisetose and on same pinnaculum, SV2 anterodorsal to SV1 and about 1/3 its length; V1 anteroventral to SV1 and about half its length (Fig. 33). A2 (not shown) equal to A1 except SV- group trisetose, SV3 on pinnaculum bearing V1, below SV2 and about equal its length. A3–A6 with four pairs of prolegs, crochets (22–24) uniordinal, uniserial, arranged in a lateral penellipse; setae as above except SV-group on pinnaculum containing proleg. A7 (not shown) as above except SV-group bisetose. A8 with setae as above except L-group arranged in a more or less vertical line, L1 on same pinnaculum bearing SD-group and spiracle; SV-group unisetose. A9 with all setae arranged in a more or less vertical line; SD1 and D2 on same pinnaculum, SD1 about 5 times longer than D2 and about equal in length to D1. A10 (Fig. 34): anal plate with SD1 slightly longer than D1, about 2–2 1/2 times longer than D2; prolegs bearing 24 uniordinal crochets, uniserial, arranged in a lateral penellipse; anterior margin of shield irregular.

Larval case (Fig. 41). Dimensions: length of main body: ♂ 12 mm ($\bar{x}$=12, SD=0, CV=0, n=2), total length of projecting fragments: 17–18 mm ($\bar{x}$=17.5, SD=0.71, CV=4%, n=2); ♀ 13 mm, total length of projecting fragments: 22 mm; maximum diameter: ♂ 2.6 mm ($\bar{x}$=2.6, SD=0, CV=0, n=2), ♀ 3.3 mm. Almost cylindrical in its entire length; soft. External cover formed by a basal layer of tiny vegetal fragments covered by large fragments of thin herbaceous stems, lengthwise arranged and parallel, various projecting backward from case.

Male pupa (Figs. 45–46). Length 5.8 mm. Uniform yellowish ochre. Frontal ridge absent, frons rounded. Antennal sclerites extending slightly beyond apex of prothoracic legs (Fig. 45). Wing sheaths extending midway along A3. Sclerites of metathoracic legs extending to anterior margin of A4. Cremaster reduced, consisting in a pair of small spines, ventrally curved, arising form a broad conical base; anal groove Y-shaped. Dorsum of A3–A7 with 2–3 irregular rows of spines directed caudad on anterior margin, both end of rows thickened (Fig. 46); A8 with spines grouped in an elliptical patch; areas surrounding rows covered by hundreds of tiny spines arranged in 2–5 series or solitaire. Dorsum of A5–A7 with single posterior row of slender spines oriented caudad. Tabulation of spines shown in Table 1.

Female pupa (Figs. 50–51). Length 7.5 mm. Uniform yellowish ochre. Head with eyes and labial palpi distinct (Fig. 50). Thorax with leg sclerites distinct; wings absent. Cremaster vestigial, reduced to a coarse and rough area around anal groove; anal groove Y-shaped. Dorsum of A6–A7 with 2–4 irregular rows of small spines directed caudad on anterior margin, A8 with spines grouped in an elliptical patch. A4–A6 with a single posterior row of slender spines cephalad oriented (Fig. 51). Tabulation of spines shown in Table 2.

Types. *Holotype* ♂ (with associated larval case and pupal exuvium), reared from larva (emerged 22 June 2003), CUBA: Sancti Spiritus province, Topes de Collantes, Pico Potrerillo, 973 m, 18 May 2003 (R. Núñez), slides RNA 014, 038, 046, 077, 078. *Paratypes*, ♀ (with associated larval case and pupal exuvium), reared from pupa (emerged 20 May 2003), CUBA: Sancti Spiritus province, Topes de Collantes, Parque Codina, 800 m, (R. Núñez), slide RNA 042; 2 larvae (with associated larval case), same data as holotype; 3 larval cases, same data as holotype; 1 larval case, same data as holotype except 17 June 2004.



FIGS. 6–10. *Paucivena* spp. male legs. **6** *P. ferruginea*, n. sp.; **7** *P. pinarensis*, n. sp.; **8** *P. fusca*, n. sp.; **9** *P. cubana*, n. sp.; **10** *P. orientalis*, n. sp. Top- prothoracic leg, middle- mesothoracic leg, bottom-metathoracic leg. Scale= 2 mm.

Natural history observations. Larvae were found feeding on mosses, *Orthostichidium guyanense* (Mont.) V.F. Brotherus (Pterobryaceae) and another unidentified species, on bark of an unidentified bush.

Two adults were reared from larvae: a male emerged from the pupa after a month; a female emerged and was observed hanging from distal end of the case.

The species was found in two localities with very different vegetation and climatic conditions. Parque Codina is characterized by a secondary and very humid evergreen forest with the lower strata protected by a dense canopy. A dry scrub, included in the mogote vegetational complex, grows on top of Pico Potrerillo, an enviroment very exposed to wind and solar radiation.

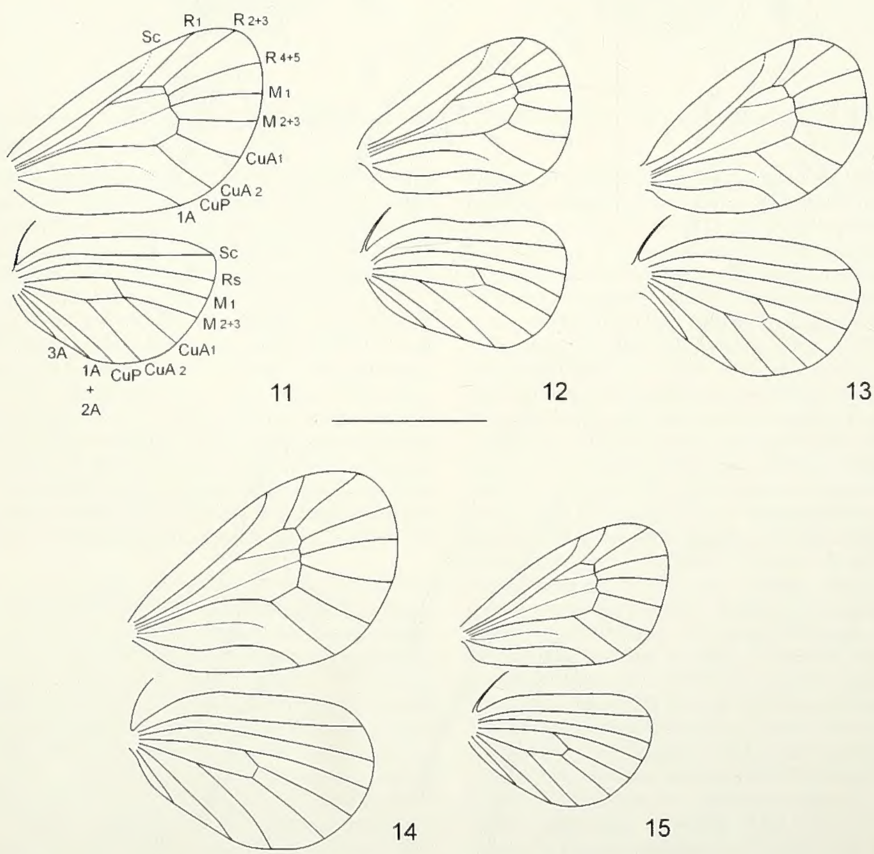
Distribution (Fig. 52). Known only from two localities at Topes de Collantes region, Trinidad Mountains, central Cuba.

Etymology. The species name is derived from the slight ferruginous iridiscence of male wings.

Remarks. The female may be separated from that of *P. orientalis*, n. sp., by its greater size (length 7.5 versus 5 mm), its more elongated genitalia, the presence of only two longitudinal spot bands on tegument (six in the other species) and its unswollen tibiae. Larvae may be recognized by the loss of AF2 on head and the isolation of LA3 on labrum. The larval case is also diagnostic for this species within the genus. Davis (1964, 1975) reported similar cases from Haiti and Trinidad. Davis noted the similarity of these cases with those constructed by species of *Epichnopteryx* Hübner and *Psyche* Schrank, two Old World genera, considering them as a probable introduction from the Old World. Larval cases of *P. ferruginea* prove that this construction pattern is not exclusive to Old World species.

***Paucivena pinarensis* Núñez, new species**
(Figs. 2, 7, 12, 18, 42, 47, 52)

Diagnosis: *Paucivena pinarensis* males possess a color pattern similar to that of *P. cubana*, sp. n., *P. orientalis*, sp. n., and *P. reticulata*. However, the reticulated pattern is weaker in *P. pinarensis* due to its more obscure background color. Compared to other *Paucivena* within this group, *P. pinarensis* males exhibit several diagnostic characters: absence of saccus in its



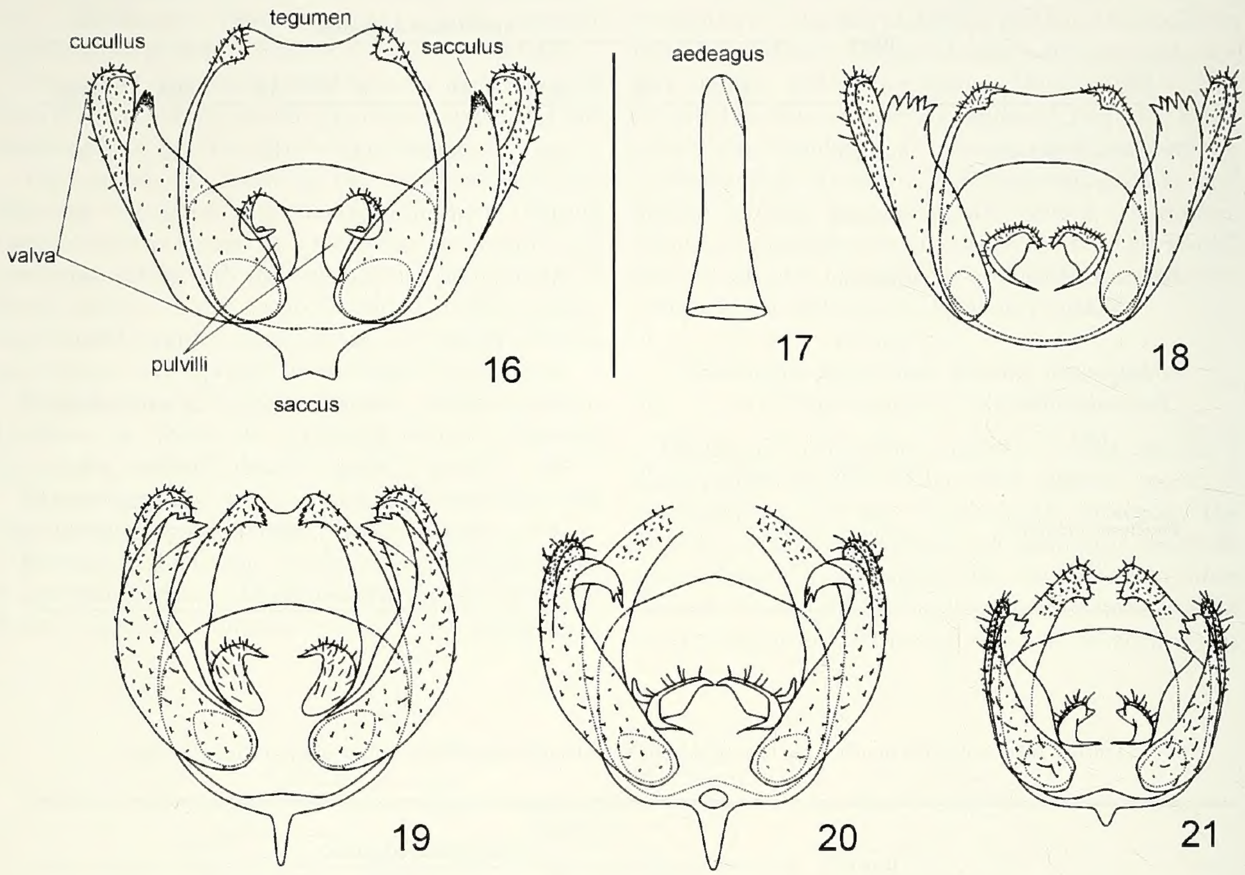
FIGS. 11–15. *Paucivena* spp. wing venation. **11** *P. ferruginea*, n. sp.; **12** *P. pinarensis*, n. sp.; **13** *P. fusca*, n. sp.; **14** *P. cubana*, n. sp.; **15** *P. orientalis*, n. sp. Scale= 3 mm.

TABLE 1. Rows and spines numbers per rows on dorsum of abdominal segments of Cuban *Paucivena* male pupae.

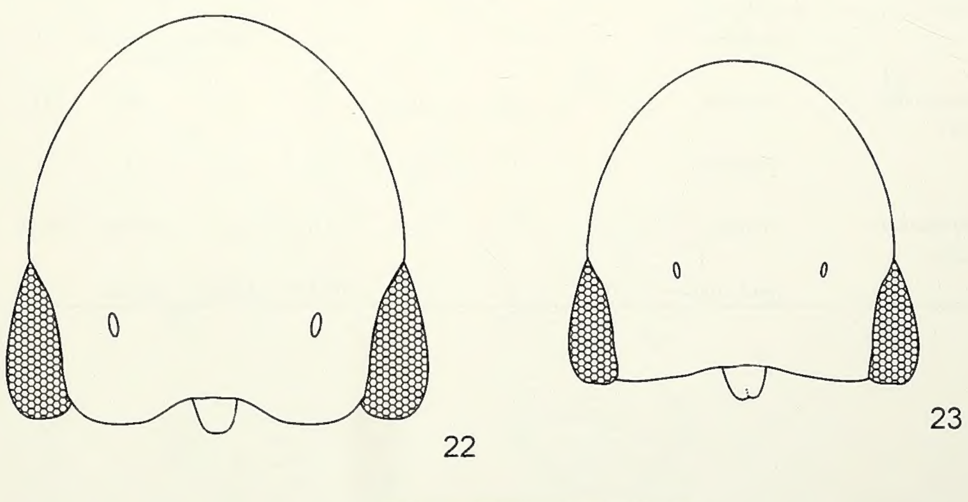
	Rows	Abdominal segments							
		I	II	III	IV	V	VI	VII	VIII
Paucivena ferruginea n=1	anterior	0	0	269	135	140	176	122	48
	posterior	0	0	0	0	42	44	48	0
Paucivena pinarensis n=1	anterior	0	0	57	63	64	60	49	49
	posterior	0	0	1	7	38	38	14	0
Paucivena cubana n=3	anterior	0	0	0	52–70	47–58	42–55	29–45	22–24
	posterior	0	0	31	35–44	37–46	36–42	32–36	0
Paucivena orientalis n=3	anterior	0	0	0	102–136	96–125	95–111	90–96	25–32
	posterior	0	0	0	27–38	23–39	24–32	23–50	0

TABLE 2. Rows and spines numbers per rows on dorsum of abdominal segments of Cuban *Paucivena* female pupae.

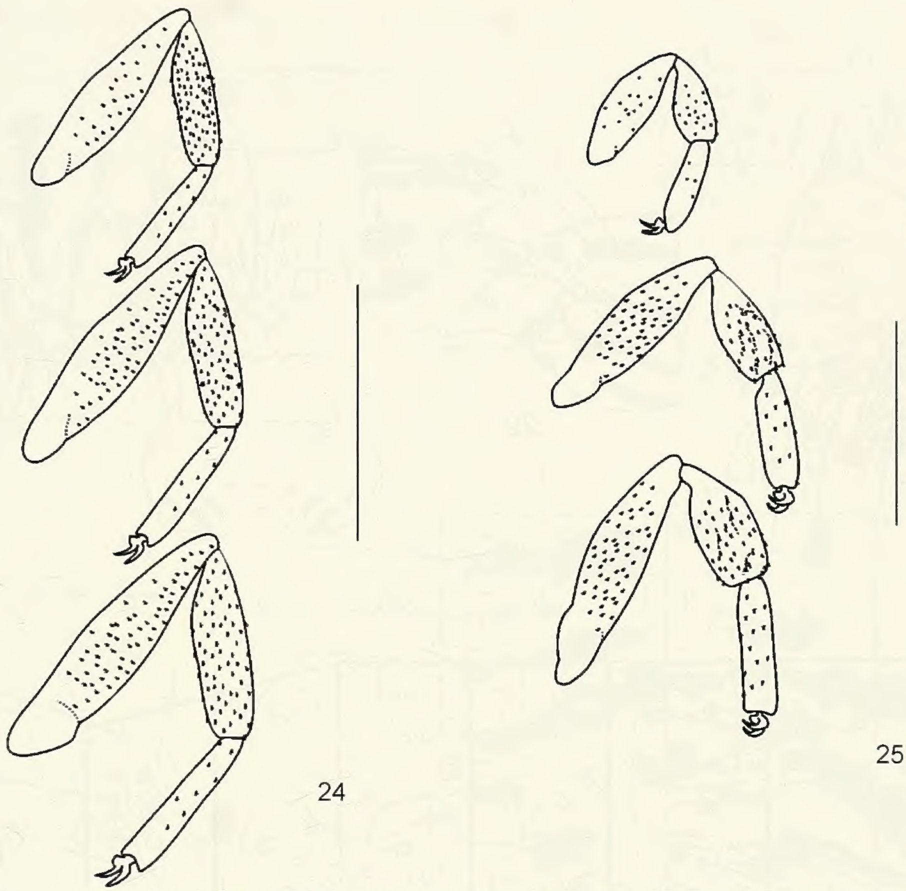
	Rows	Abdominal segments							
		I	II	III	IV	V	VI	VII	VIII
Paucivena ferruginea n=1	anterior	0	0	0	0	0	61	90	21
	posterior	0	0	0	7	58	53	0	0
Paucivena cubana n=1	anterior	0	0	0	3	14	20	21	0
	posterior	0	0	6	56	78	71	0	0
Paucivena orientalis n=3	anterior	0	0	0	8–10	9–10	29–30	92–96	18–22
	posterior	0	0	0	16–17	23–27	21–22	0	0



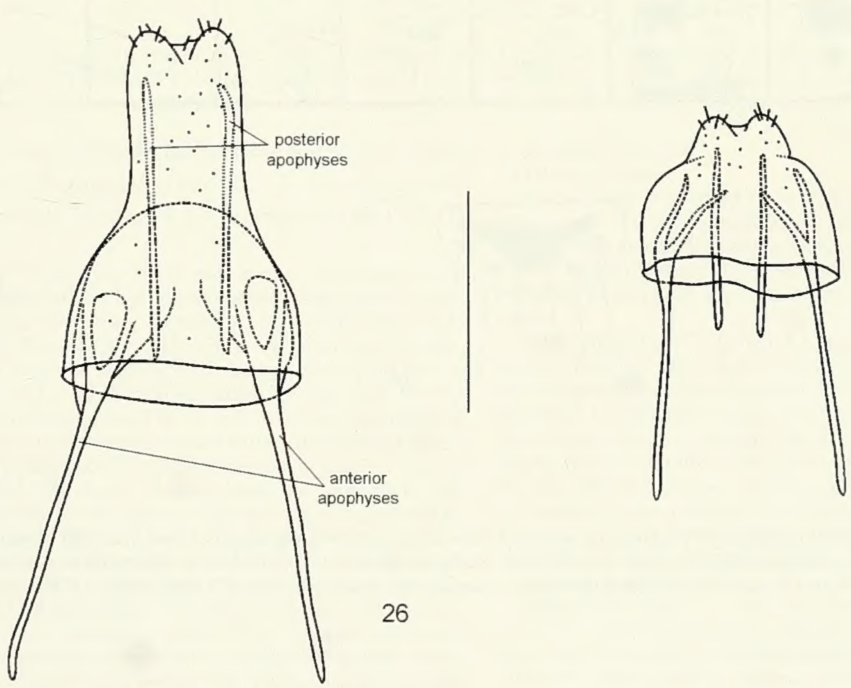
FIGS. 16–21. *Paucivena* spp. male genitalia, ventral view. **16** *P. ferruginea*, n. sp., main body; **17** *P. ferruginea*, n. sp., aedeagus; **18** *P. pinarensis*, n. sp.; **19** *P. fusca*, n. sp.; **20** *P. cubana*, n. sp.; **21** *P. orientalis*, n. sp. Scale= 0.5 mm.



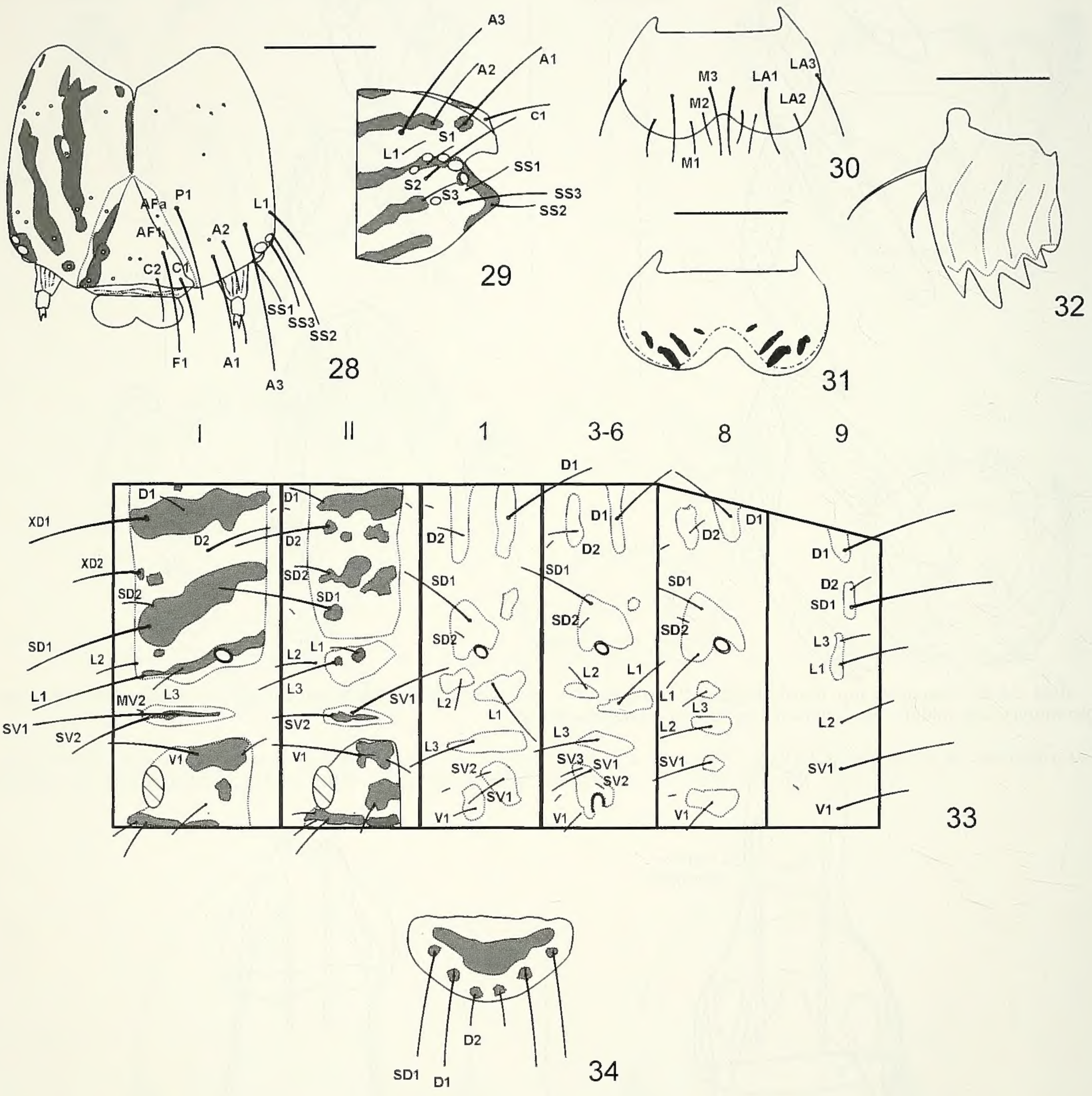
FIGS. 22-23. *Paucivena* spp. female head, ventral view. **22** *P. ferruginea*, n. sp.; **23** *P. orientalis*, n. sp. Scale= 1 mm.



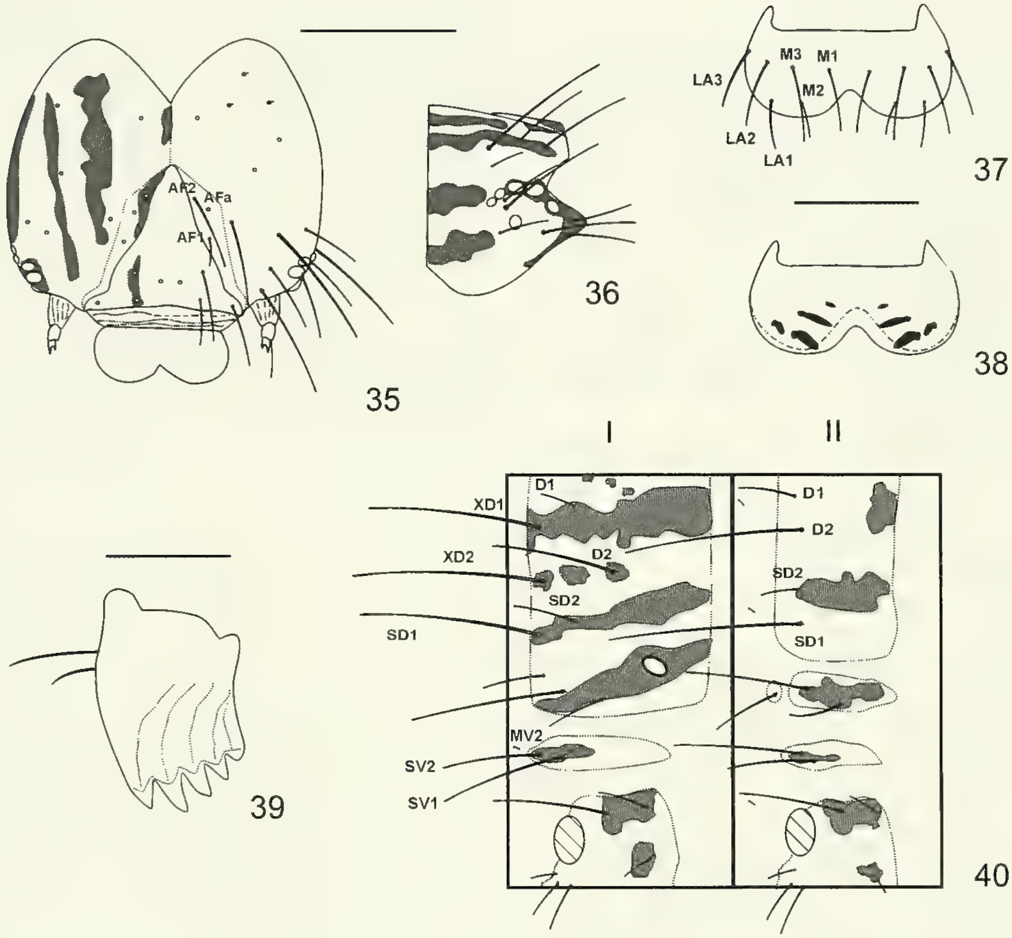
FIGS. 24–25. *Paucivena* spp. female legs. **24** *P. ferruginea*, n. sp., scale= 0.5mm; **25**- *P. orientalis*, n. sp., scale= 0.25 mm. Top-prothoracic leg, middle- mesothoracic leg, bottom-metathoracic leg.



FIGS. 26–27. *Paucivena* spp. female genitalia, ventral view. **26** *P. ferruginea*, n. sp.; **27** *P. orientalis*, n. sp. Scale= 0.5 mm.



FIGS. 28–34. Chaetotaxy of *Paucivena ferruginea*, n. sp., largest larva (last instar?). **28** Head, dorsal view; **29** Stemmata of left side, lateral view; **30** Labrum, dorsal view; **31** Labrum, ventral view; **32** Right mandible, ventral view; **33** Prothorax, mesothorax and abdominal segments 1, 3–6, 8 and 9, lateral view; **34** Anal shield, dorsal view. Scale, 28–29= 0.5 mm; 30–32= 0.2 mm.



FIGS. 35–40. Chaetotaxy of *Paucivena cubana*, n. sp., largest larva (last instar?). **35** Head, dorsal view; **36** Stemmata of left side, lateral view (scale= 0.5 mm); **37** Labrum, dorsal view; **38** Labrum, ventral view; **39** Right mandible, ventral view (scale= 0.2 mm); **40** Prothorax and mesothorax, lateral view (abdomen damaged). Scale, 35–36= 0.5 mm; 37–39= 0.2 mm.

genitalia; the relative length of its tibial spurs, 0.3 versus 0.15 (*P. cubana*, *P. orientalis*) and 0.5 (*P. reticulata*); and interocular index 0.7 versus 1.1 (*P. reticulata*) and 1.5 (*P. cubana*).

Male (Fig. 2, 7, 12, 18).: *Head*: pale brown, labial palpi dark brown. Antennal tips broken; lateral pectinations 3 about times length of supporting segment. Vertical diameter of eye 0.7 the interocular distance. *Thorax* (Figs. 7, 12): dark brown; underside pale brown, inner surface of fore and midlegs dark brown, joints pale brown. Vestiture dense, scales hairlike. Tibial spurs approximately 0.3 the length of basal tarsal segments (Fig. 7). FW with basal two thirds of costa dark brown; ground brown streaked with dark brown forming a faint reticulated pattern; fringe with various tones of brown. Scales at discal cell variable in shape: oblanceolated and ovobated, with rounded or acute apices, with scattered hairlike scales. Venation (Fig. 12) as in *P. ferruginea*. HW uniform brown; fringe with various tones of brown. Venation as in *P. ferruginea* except M_{2+3} and CuA_1 which arise separate from cell, M_{2+3} equidistant from CuA_1 and M_1, only one anal vein present. Wing expanse: 9.2 mm. *Abdomen*: pale brown. Vestiture dense, scales hairlike. *Genitalia* (Fig. 18): tegumen broad, with a pair of sparsely setose apical lobes. Valvae with pulvilli setose; apex of sacculus armed with five strong spines; cucullus apically rounded and sparsely setose. Saccus absent. Aedeagus simple, cylindrical, 0.6 times length of valvae.

Female. Unknown.

Larva. Unknown.

Larval case (Fig. 42). Dimensions: length: ♂ 9.8 mm; maximum diameter: ♂ 3.4 mm. Fusiform in outline; soft. Exterior heavily covered with vegetal fragments, leaves and short stems, and mosses various shaped and oriented lengthwise. Cases were found hanging from silk filaments (3.5 mm in length) attached to rocks and tree trunks.

Male pupa (Fig. 47). Length 5.1 mm. Ochre, wing sheaths reddish brown. Frontal ridge absent, frons rounded. Antennal sclerites extending slightly beyond apex of prothoracic legs. Wing sheaths extending to posterior margin of A3. Sclerites of metathoracic legs extending to posterior margin of A4. Cremaster consisting in a pair of strong spines ventrally curved; anal groove Y-shaped. Dorsum of A3–A8 with an irregular row of spines on anterior margin; areas surrounding rows covered by hundreds of tiny, solitaire spines. Dorsum of A3–A7 with single posterior row of slender spines. Tabulation of spines shown in Table 1.

Female pupa. Unknown.

Types. *Holotype*, ♂ (with associated larval case and pupal exuvium), reared from larvae (emerged 28 February 2004), CUBA: Pinar del Río province, Sierra del Rosario, Taco Taco River shore 1 km northeast from Jardín de Aspiro, 200 m, 28 November 2003 (R. Núñez), slides RNA 054, 079, 080. *Paratypes*: 4 larval cases, CUBA: Pinar del Río province, Sierra del Rosario, Jardín de Aspiro, 150 m,

28–29 November 2003, (R. Núñez).

Natural history observations. The single larva was found on limestone rock near the Taco Taco River shore and its food source can not be accurately identified. In the lab, the larva was fed with several crustose lichens and mosses collected on its substrate. Other larval cases were found on rocks and tree trunks in an old abandoned Botanical Garden (Jardín de Aspiro). The unique adult emerged after a month; emergence took place between 0900 and 1130h.

At the Taco Taco River shore secondary remnants of gallery forest are present whereas at Jardín de Aspiro several introduced and native trees grow forming groves separated by cleared areas occupied by camping installations.

Distribution (Fig. 52). Known only from two close localities at Sierra del Rosario, Pinar del Río province.

Etymology. The species name is derived from the name of the Cuban province where the type locality, Pinar del Río, is located.

Remarks. The larval case is identical to that of *P. cubana*. The male pupa may be easily identified by the unique arrangement of spine rows on the dorsum of abdominal segments (Table 1).

Paucivena fusca Núñez, new species

Paucivena sp. n. 1: Núñez, 2004: 155

Figs. 3, 8, 13, 19, 52

Diagnosis. Males of *P. fusca* may be recognized by their uniform dark brown coloration. Within the genus only *P. hispaniolae* exhibits a similar coloration but it has

Key to the adult males of _Paucivena_

1. Wings dark brown with a ferruginous shine; genitalia with an acute and heavily sclerotized sacculus and a bifid saccus (Fig. 16) ..... *P. ferruginea*
- Wings with a different color pattern; genitalia with sacculus not acute and weakly sclerotized, saccus not bifid 2
2. Dorsum of wings and body entirely dark brown, almost black 3
- Dorsum of wings and body with light color pattern 4
3. Body whitish grey ventrally; eyes of medium size (vertical diameter of eye 1.1 the interocular distance); genitalia with the margins of apex of sacculus and the apical lobes of tegumen smooth ..... *P. hispaniolae*
- Body dark brown ventrally; eyes small (vertical diameter of eye 0.8 the interocular distance); genitalia with the margins of apex of sacculus and the apical lobes of tegumen serrulated (Fig. 19) ..... *P. fusca*
4. Tibial spurs much reduced, approximately 0.15 the length of basal tarsal segment 5
- Tibial spurs less reduced, approximately 0.3 the length of basal tarsal segment or longer 6
5. Eyes very large (vertical diameter of eye 1.5 the interocular distance); wing expanse: 12 mm ..... *P. cubana*
- Eyes very small (vertical diameter of eye 0.7 the interocular distance); wing expanse: 8.2-9.1 mm ..... *P. orientalis*
6. Eyes of medium size (vertical diameter of eye 1.1 the interocular distance); tibial spurs large, approximately 0.5 the length of basal tarsal segment; FW reticulated pattern distinct ..... *P. reticulata*
- Eyes very small (vetical diameter of eye 0.7 the interocular distance); tibial spurs reduced, approximately 0.3 the length of basal tarsal segment; FW reticulated pattern weak, indistinct ..... *P. pinarensis*

Key to the known larvae of _Paucivena_ (excludes _P. reticulata_, _P. pinarensis_, _P. fusca_ and _P. orientalis_, which are unknown)

1. Head and thorax whitish to light tan with irregular patches of dark fuscous; meso and metathorax with an extra seta (SD1a?) ..... *P. hispaniolae*
- Head and thorax whitish with longitudinal dark fuscous bands arranged in a striated pattern; meso and metathorax without an extra seta 2
2. Head with AF2 absent (Fig. 28); LA3 on labrum isolated from the rest (Fig. 30); abdominal integument dark brown ..... *P. ferruginea*
- Head with AF2 present (Fig. 35); LA3 on labrum not isolated (Fig. 37); abdominal integument dirty white ..... *P. cubana*

Key to the known male pupae of *Paucivena* (excludes *P. reticulata* and *P. fusca*, which are unknown)

1.	Anterior margin of A3 without spines	2
-	Anterior margin of A3 with at least one row of spines	3
2.	Spines absent from posterior margin of A3; rows at anterior margin of A4-A7 with 90 or more spines (Table 1); length 3.8-4.8 mm	*P. orientalis*
-	Spines present on posterior margin of A3; rows at anterior margin of A4-A7 with 70 or fewer spines (Table 1); length 5.0-5.4 mm	*P. cubana*
3.	Rows on anterior margin of A3-A7 with more than 100 spines (Table 1); length 5.8 mm	*P. ferruginea*
-	Rows on anterior margin of A3-A7 with less than 100 spines (Table 1); length 5.0-5.1 mm	4
4.	Spines present, although reduced, on posterior margin of A3-A4; cremaster consisting in a pair of strong spines ventrally curved	*P. pinarensis*
-	Spines completely absent from posterior margin of A3-A4; cremaster consisting in a pair of small spines ventrally curved	*P. hispaniolae*

Key to the female pupae of *Paucivena* (excludes *P. reticulata*, *P. pinarensis* and *P. fusca*, which are unknown)

1.	Anterior rows of spines absent from dorsum of A3-A4	2
-	Anterior rows of spines present on dorsum of A3-A4	3
2.	Posterior row of spines reduced but present on dorsum of A4; cremaster vestigial, reduced to a coarse and rough area around anal groove; length 7.5 mm	*P. ferruginea*
-	Posterior row of spines absent from dorsum of A4; cremaster relatively well developed, consisting in pair of short acute spines; length 10-11 mm	*P. hispaniolae*
3.	Anterior margin of A8 with a row of spines surrounded by hundreds of tiny spines; length 4.9-5.1 mm	*P. orientalis*
-	Anterior margin of A8 covered only by hundreds of tiny spines; length 8.0 mm	*P. cubana*

the underside of body whitish grey. Other useful characters are FW shape (more rounded in the Cuban species), eye size (interocular index 0.8 in *P. fusca* and 1.1 in *P. hispaniolae*) and the serrated margins at apex of sacculus and apical lobes of tegumen in the genitalia of *P. fusca*, both smooth in *P. hispaniolae*.

Male (Figs. 3, 8, 13, 19). *Head*: dark brown. Antennae with 21–22 segments; lateral pectinations 2 times length of segment. Vertical diameter of eye 0.8 the interocular distance. *Thorax* (Figs. 8, 13): uniform dark brown. Vestiture dense, scales hairlike. Tibial spurs approximately 0.25 the length of basal tarsal segments (Fig. 8). Scales at discal cell of FW oblanceolated and ovobated with rounded or acute apices. Venation (Fig. 13) as in *P. ferruginea*. HW venation as in *P. pinarensis*, except the origin of M_{2+3} which is closer to CuA_1 than to M_1. Wing expanse: 10–11 mm ($\bar{x}$=10.2, SD=0.23, CV=4%, n=9). *Abdomen*: dark brown. Vestiture dense, scales hairlike. *Genitalia* (Fig. 19): tegumen broad with apical cleft, lobes minutely serrated and sparsely setose. Valvae with pulvilli setose; apex of sacculus strongly serrated; cucullus rounded, apex sparsely setose. Saccus reduced, approximately 0.2 the length of main body. Aedeagus simple, cylindrical, 0.6 times the length of valvae.

Female. Unknown.

Inmature stages. Unknown.

Larval case. Unknown.

Types. *Holotype*, ♂ CUBA: Sancti Spiritus province, Topes de Collantes, Pico Potrerillo, 973 m, 6 May 2002 (R. Núñez), slides RNA 011, 015, 039. *Paratypes*, 3 ♂, same data as holotype, slides RNA 010, 022. 5 ♂, same data as holotype except 17 June 2004, slides RNA 026, 029, 041.

Natural history observations. All individuals were found flying at noon on the top of Pico Potrerillo except a single specimen seen flying between rocky walls at peak access. This species shares its habitat, dry scrub on the top of Pico Potrerillo, with *P. ferruginea* and *P. cubana*.

Distribution (Fig. 52). Known only from Pico Potrerillo at Trinidad Mountains, central Cuba.

Etymology. The species name is derived from its uniform dark brown color.

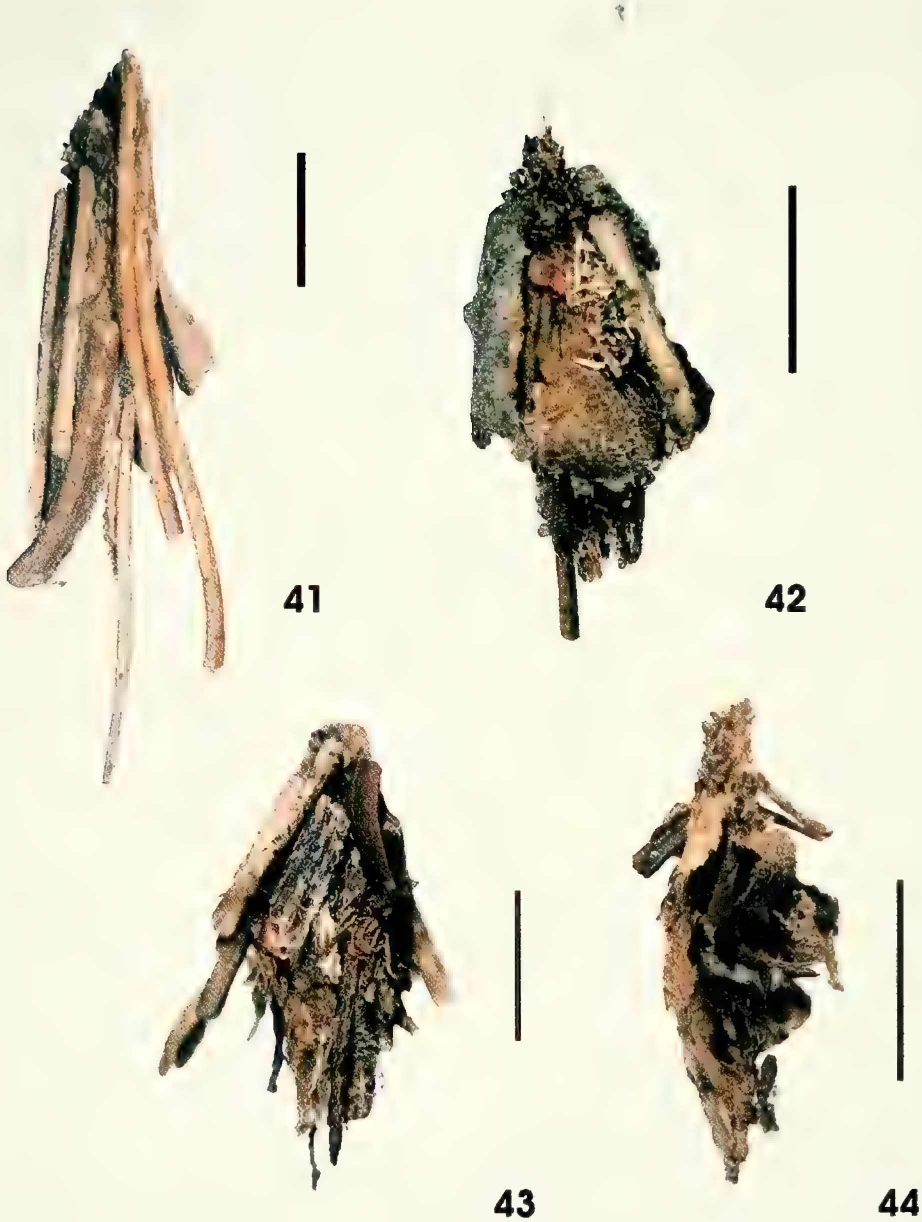
Paucivena cubana Núñez, new species

Paucivena sp. n. 2: Núñez, 2004: 155

Figs. 4, 9, 14, 20, 35–40, 43, 48, 52

Diagnosis. Males of *P. cubana* may be separated from other *Paucivena* with reticulated wing pattern by the following characters: 12 mm of wing expanse (the largest within the genus), elongated legs with tiny tibial spurs (approximately 0.15 the length of basal tarsal segment) and large eyes (interocular index 1.5, the largest within the genus).

Male (Figs. 4, 9, 14, 20). *Head*: pale yellowish ochre. Antennae with 18 segments; lateral pectinations 1.5–2 times the length of segment. Eyes large, vertical diameter of eye 1.5 the interocular distance. *Thorax* (Fig. 9, 14): pale yellowish ochre with scattered dark brown scales. Vestiture dense, scales hairlike. Tibial spurs approximately 0.15 the length of basal tarsal segments (Fig. 9). Wings thinly scaled. FW (faded) yellowish ochre with scattered dark brown



FIGS. 41–44. *Paucivena* spp. larval cases. **41** *P. ferruginea*, n. sp.; **42** *P. pinarensis*, n. sp.; **43** *P. cubana*, n. sp.; **44** *P. orientalis*, n. sp. Scale= 3 mm.

scales; dark brown scales concentrated at basal half of anterior and posterior margins, forming a faint reticulated pattern on basal two thirds; fringe ochre. Scales at discal cell variable in shape: oblanceolated and ovobated, with rounded or acute apices, or hairlike. Venation as in *P. ferruginea*, except accessory cell which is wider, closing below origin of R_{4+5} (Fig. 14). HW pale yellowish ochre with scattered dark brown scales, paler than FW; fringe pale yellowish ochre. Venation as in *P. fusca*. Wing expanse: 12 mm. *Abdomen*: pale yellowish ochre with scattered dark brown scales. Vestiture dense, scales hairlike. *Genitalia* (Fig. 20): tegumen broad, apex damaged. Valvae with pulvilli sparsely setose; apex of sacculus armed with three spines; cucullus rounded with apex sparsely setose. Saccus reduced, approximately 0.2 the length of main body. Aedeagus simple, cylindrical, 0.7 times the length of valvae.

Female. Unknown.

Larva (Figs. 35–40). Length of longest larva 6.9 mm, maximum width of head capsule 1.0 mm. Head and thorax whitish with dark fuscous longitudinal bands continued on thorax forming a striated pattern. *Head* (Figs. 35–39): as in *P. ferruginea* except, AF2 present; adfrontal sclerite with elongated spot on upper third covering origin of AF2; frons with spot covering origin of F1 and C2 (Fig. 35); AFa closer to AF2 than to AF1. Sixth stemma immediately anterior to S2 and S3, midway between them (Fig. 36). Labrum (Figs. 37, 38) with setae approximately mesad except, LA1 and M2 distinctly closer to border. Mandibles with four acute teeth and a fifth, blunt tooth (Fig. 39). *Thorax* (Fig. 40): as in *P. ferruginea* with the following exceptions. TI with XD1 about equal in length to XD2 and SD1, and about 1 1/2 times longer than D2; MV2 separated from pinnaculum bearing SV-

group. TII-TIII: D2 about 3 times longer than D1; SD1 about 4 times longer than SD2. *Abdomen* damaged, integument dirty white.

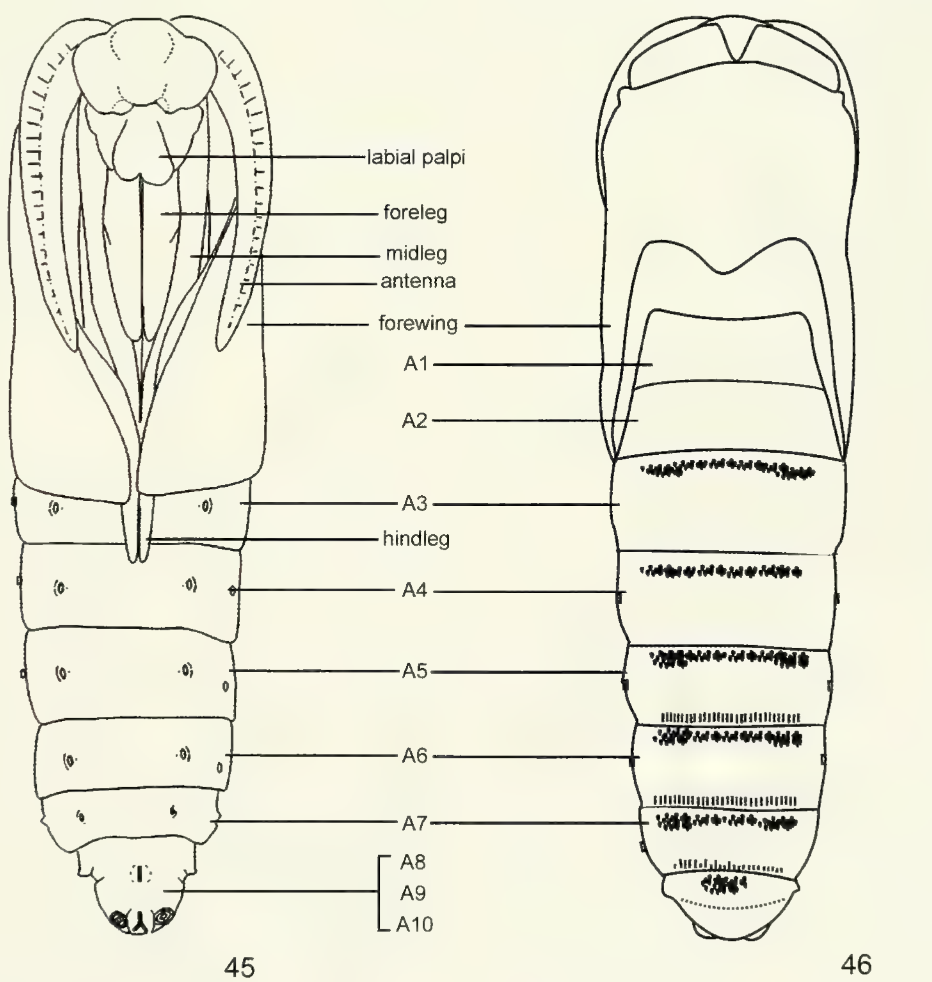
Larval case (Fig. 43). Dimensions, length: ♂ 10–11 mm ($\bar{x}$=10.5, SD=0.71, CV=7%, n=2), ♀ 18 mm; maximum diameter: ♂ 4.0 mm ($\bar{x}$=4.0, SD=0, CV=0, n=2), ♀ 6.5 mm. Fusiform in outline, soft. Exterior densely covered by fragments of leaves, small herbaceous stems and mosses of different shape and lengthwise oriented. Cases were found attached to rocky walls at Pico Potrerillo and banana trees, *Musa paradisiaca* L. (Musaceae), at Mogote Mi Retiro, hanging from silk threads (length: ♂ 3.5 mm, ♀ 5 mm).

Male pupa (Fig. 48). Length 5.0–5.4 mm ($\bar{x}$=5.2, SD=0.23, CV=4%, n=2). Uniform brownish ochre. Frontal ridge absent, frons rounded. Antennal sclerites extending slightly beyond apex of prothoracic legs. Wing sheaths extending to anterior margin of A4. Sclerites of metathoracic legs extending midway along A5 or its posterior margin. Cremaster consisting in a pair of strong and very close spines, ventrally curved and abruptly tapered at apex; anal groove Y-shaped. Dorsum of A4–A8 with 1–2 irregular rows of spines on anterior margin; anterior margin A3 and areas surrounding spine rows on A4–A8 covered by hundreds of tiny, solitaire spines. Dorsum of A3–A7 with single posterior row of slender spines. Tabulation of spines shown in Table 1.

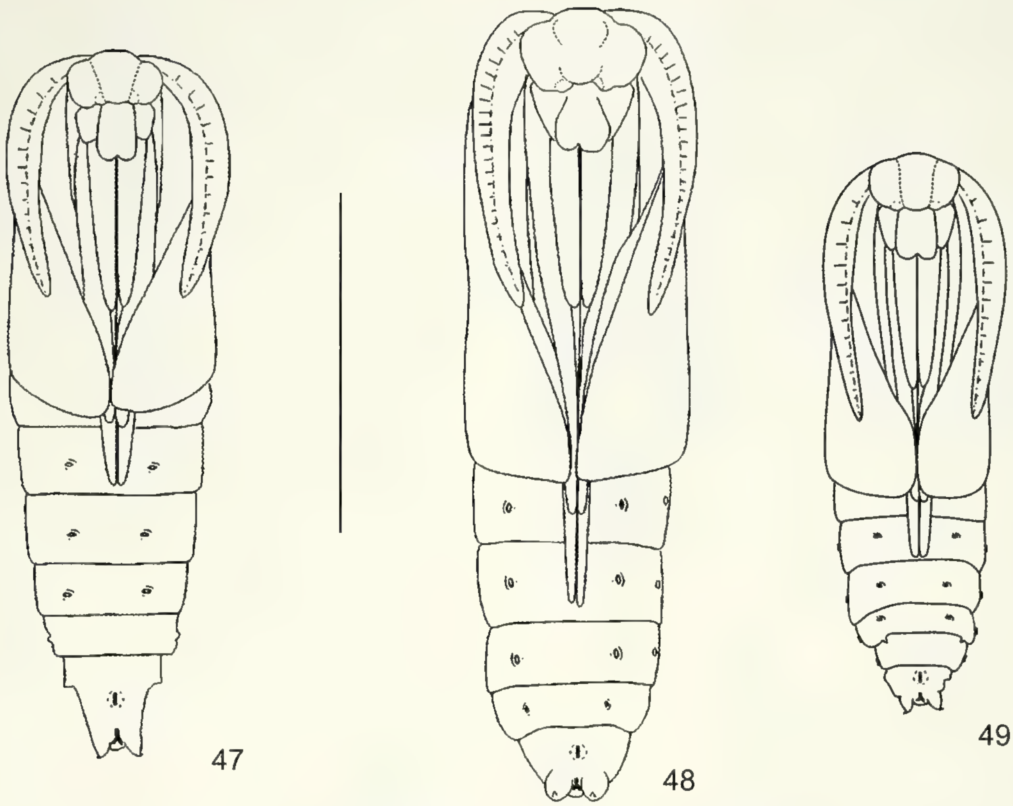
Female pupa. Length 8 mm. Uniform ochre. Head with eyes and labial palpi distinct. Thorax with leg sclerites distinct; wings absent. Cremaster vestigial, reduced to a small pair of blunt, widely separated spines; anal groove Y-shaped, with a pair of small rounded tubercles on either side. Dorsum of A4 with single anterior row of reduced, widely spaced spines; A5–A7 with 2–3 irregular rows of spines on anterior margin; anterior margin of A3, areas surrounding rows on A4–A8 and anterior margin of A8 covered by hundreds of tiny spines, solitaire or in 2–4 series. A3–A6 with single posterior row of slender spines. Tabulation of spines shown in Table 2.

Types. *Holotype*, ♂ (with associated larval case and pupal exuvium), reared from larva (emerged June 2002), CUBA: Sancti Spiritus province, Topes de Collantes, Caburní River depression, 500 m, 30 April 2002 (R. Núñez), slides RNA 013, 016, 023, 040, 045. *Paratypes*, 1 larva, same data as holotype, slides RNA 065, 066, 070; 6 larval cases (some with associated pupal exuvium), CUBA: Sancti Spiritus province, Topes de Collantes, mogote Mi Retiro northern base, 800 m, 17 May 2003 (R. Núñez); 4 larval cases (some with associated pupal exuvium), CUBA: Sancti Spiritus province, Topes de Collantes, southern side of rocky outcrop at Pico Potrerillo access, 850 m, 18 May 2003 (R. Núñez), slides RNA 075, 076; 3 larval cases (one with associated pupal exuvium), same data as preceding except 17 June 2004; 2 larval cases, CUBA: Sancti Spiritus province, Topes de Collantes, Parque Codina, 800 m, 20 May 2003 (R. Núñez).

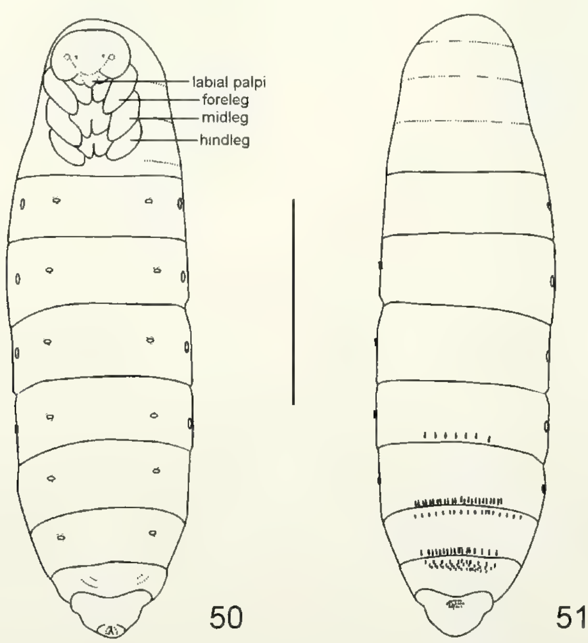
Natural history observations. Larvae fed on *Plagiochila* sp. (Plagiochilaceae), a hepatic growing on



FIGS. 45–46. *Paucivena* spp. male pupa. **45** *P. ferruginea*, n. sp., ventral view; **46** *P. ferruginea*, n. sp., dorsal view



FIGS. 47–49. *Paucivena* spp. male pupa. **47** *P. pinarensis*, n. sp., ventral view; **48** *P. cubana*, n. sp., ventral view; **49** *P. orientalis*, n. sp. Scale= 0.25 mm.



FIGS. 50–51. *Paucivena ferruginea*, n. sp., female pupa. **50** Ventral view; **51** Dorsal view. Scale= 0.25 mm.

rocks on the Caburní River shore. However, larvae probably use other hosts since cases were found on different substrates at other localities. At the Pico Potrerillo access cases were found attached to rocky walls covered by crustose lichens, at mogote Mi Retiro base they were located on banana plants whereas at Parque Codina they live on trunks of native trees. The single adult emerged after a month as pupa.

Paucivena cubana inhabits localities with very different vegetation and climatic conditions. At Parque Codina it was found in the lower strata of secondary evergreen forest, a very humid habitat, and at the mogote Mi Retiro base in cultivated land, banana and coffee (*Coffea arabica* L., Rubiaceae), close to the mogote rocky wall. On the other hand, Caburní River shores are covered by gallery forest remnants, today dominated by an introduced tree (*Syzigium jambos* L., Myrtaceae), whereas at the Pico Potrerillo access cases were attached to rocky walls surrounded by evergreen forest.

Distribution (Fig. 52). Known from four localities at Topes de Collantes, Trinidad Mountains, central Cuba.

Etymology. The species name is derived from the name of the Cuban island.

Remarks. The larval color pattern is identical to that of *P. ferruginea*; however, differences in chaetotaxy and abdominal coloration are present. Male and female pupae are easily distinguished by the arrangement of abdominal dorsal spines (Tables 1, 2).

***Paucivena orientalis* Núñez, new species**
Figs. 5, 10, 15, 21, 23, 25, 27, 44, 49, 52

Diagnosis. Adult males of *P. orientalis* possess a color pattern similar to that of *P. pinarensis*, *P. cubana*, and *P. reticulata*. *P. orientalis* may be separated from *P. pinarensis* by its smaller tibial spurs (0.15 versus 0.3 the length of basal tarsal segment), the presence of a saccus in its genitalia and its more distinct FW reticulated pattern. From *P. reticulata*, it may be distinguish by its smaller eyes (interocular index 0.7 versus 1.1) and tibial spurs (0.15 versus 0.5 the length of basal tarsal segment). From *P. cubana* it differs by its smaller size (8.2–9.1 versus 12 mm of wing expanse) and eye size (interocular index 0.7 versus 1.5).

Male (Figs. 5, 10, 15, 21). *Head*: pale greyish brown. Antennae with 16 segments; lateral pectinations 2–2.5 times the length of segment. Eyes small, vertical diameter of eye 0.7 the interocular distance. *Thorax* (Figs. 10, 15): dorsum dark brown; underside pale greyish brown, inner surface of legs dark brown. Vestiture dense, scales hairlike. Tibial spurs approximately 0.15 the length of basal tarsal segments (Fig. 10). Wings thinly scaled. FW variously rounded; pale grayish brown streaked with dark brown scales to form a reticulated pattern; fringe with various tones of brown. Scales at discal cell mostly oblanceolated and ovobated, with rounded, or rarely acute apices. Venation (Fig. 15) as in *P. ferruginea*. HW uniform pale greyish brown; fringe with various tones of brown; venation as in *P. fusca*. Wing expanse: 8.2–9.1 mm ($\bar{x}$=8.8, SD=0.49 CV=6%, n=3). *Abdomen*: dorsum dark brown at both ends, remainder pale greyish brown. Vestiture dense, scales hairlike. *Genitalia* (Fig. 21): tegumen broad, with a pair of sparsely setose apical lobes. Valvae with pulvilli sparsely setose; apex of sacculus armed with three to four spines; cucullus with apex rounded and sparsely setose. Saccus reduced, approximately 0.1 the length of main body. Aedeagus simple, cylindrical, 0.6 times the length of valvae.

Female (Figs. 23, 25, 27). Length 5.0 mm. Vermiform. Stramineous with six longitudinal bands of brown spots on dorsum and sides of body. *Head* (Fig. 23): stramineous, eyes black. Slightly sclerotized. Shape near ovoid (ventral view); eyes compound, well developed, subventral. Labial palpi 1-segmented, almost 100% fused; antennae absent. *Thorax* (Fig. 25): patterned as above; body wall slightly sclerotized. Legs functional, armed with numerous tiny spines; tibiae swollen; tarsi 1-segmented with a pair of claws at distal end (Fig. 25); wings absent. *Abdomen*: color pattern disappearing at A2–A3; membranous and naked except for a ring of dense brownish ochre hairlike scales around A7. External genitalia reduced (Fig. 27), largely membranous. Two pairs of apophyses present; anterior pair elongated, free except, bifid base fused with tegument; posterior pair straight and free.

Larval case (Fig. 44). Dimensions, length: ♂ 6.5–7.1 mm ($\bar{x}$=6.7, SD=0.32, CV=5%, n=3), ♀ 9–12 mm ($\bar{x}$=10.8, SD=1.10, CV=10%, n=5); maximum diameter: ♂ 1.5–1.7 mm ($\bar{x}$=1.6, SD=0.12, CV=8%, n=3), ♀ 1.8–2.7 mm ($\bar{x}$=2.2, SD=0.34, CV=15%, n=5). Fusiform in outline, soft. Exterior densely covered by elongated and divergent fragments of leaves and stems of bryophytes and herbaceous plants, occasionally hair fragments are added; material is arranged lengthwise.

Male pupa. Length 3.8–4.8 mm ($\bar{x}$=4.3, SD=0.71, CV=17%, n=2). Uniform brownish ochre. Frontal ridge absent, frons rounded. Antennal sclerites usually extending beyond apex of prothoracic legs (Fig. 49). Wing sheaths extending midway along A3. Sclerites of metathoracic legs usually extending to A4 posterior. Cremaster consisting in a pair of strong and widely separated, ventrally curved spines; anal groove Y-shaped. Dorsum of A4–A8 with 2–3 irregular rows of spines on anterior margin; anterior margin of A3 and areas surrounding rows at A4–A5 covered by hundreds of tiny spines, solitaire or in 2–5 series. Dorsum of A4–A7 with single posterior row of slender spines. Tabulation of spines shown in Table 1.

Female pupa. Length 4.9–5.1 mm ($\bar{x}$=5.0, SD=0.1, CV=2%, n=3). Uniform ochre. Head with eyes and labial palpi distinct. Thorax with legs sclerites present; wings absent. Cremaster vestigial, reduced to a coarse and rough area around anal groove; anal groove Y-shaped. Dorsum of A4–A6 and A8 with single row of spines on anterior margin, A7 with two rows; areas surrounding rows at A4–A6 and anterior margin of A8 covered by hundreds of tiny spines, solitaire or in 2–5 series. A4–A6 with single posterior row of slender spines. Tabulation of spines shown in Table 2.

Types. *Holotype*, ♂ (with associated larval case and pupal exuvium), reared from pupa (emerged 28 April 2004), CUBA: Santiago de Cuba province, La Gran Piedra, Estación Meteorológica La Gran Piedra, 1100 m, 23 April 2004 (R. Núñez), slides RNA 024, 031, 035, 036. *Paratypes*, 3 larval cases (some with associated pupal exuvium), CUBA: Granma province, La Bayamesa, abandoned coffe plantation at Nuevo Mundo stream shore, 1600 m, 21 April 2004 (R. Núñez); ♂ (with associated larval case and pupal exuvium), reared from pupa (emerged 2 May 2004), same data as holotype; ♂ (with associated larval case and pupal exuvium), reared from pupa (emerged 9 May 2004), same data as holotype; ♀ (with associated larval case and pupal exuvium), reared from pupa (emerged 24 May 2004), same data as holotype, slides RNA 030, 034; 1 larva with its larval case, same data as holotype; 9 larval cases (some with associated pupal exuvium), same data as holotype.

Natural history observations. Larvae were collected on substrates covered by several lichens and mosses and on external walls of edifications; thus, this

species probably also feeds on detritus. The adult reared from a larva, a female, emerged after three weeks. One case was collected with an egg cluster and 53 larvae hatched 1 May 2004.

At Nuevo Mundo larval cases were found on trunks of old isolated *Mangifera indica* L. (Anacardiaceae) trees, in an abandoned coffee plantation. At Gran Piedra all individuals were located on edification walls.

Distribution. Known only from two widely separated localities at Sierra Maestra, southeastern Cuba (Fig. 52).

Etymology. The species name is referred to its distribution range, restricted to the oriental Cuban region.

Remarks. The larval case is diagnostic for this species. Although constructed with small dry vegetal fragments like those of *P. pinarensis* and *P. cubana*, material is always cut in slender pieces and arranged lengthwise but in a divergent way. Pupae of both sexes are easily distinguished by the arrangement of abdominal dorsal spines (Tables 1, 2).

DISCUSSION

All new species described here fit the genus description. However, interespecific variation in the interocular index was noted with values between 0.7 and 1.5. This is the only character that shows significant deviation. Measurement given by Davis (1975) was 1.1. Deviation in Cuban representatives may be due to differences in daily activity between species. Powell (1973) also used an "eye index" in his study on New World *Ethmia* Hübner (Oecophoridae: Ethmiinae). Index values were between 0.9 and 1.2 in moths known or presumed to be nocturnal whereas diurnal species exhibited ratios from 0.7 to 0.8. All adult males of *Paucivena* species described here were lab-reared, except those of *P. fusca* that always were collected flying during the day. Data on daily activity of species described by Davis (1975) are unavailable so this matter will only be clarified with future work.

The female, described here for the first time, shows characters that confirm *Paucivena* intermediate position among the American psychids proposed by Davis (1975) based on male characters. Female primitive features are the presence of well developed compound eyes, functional legs and the behaviour of leaving the larval case and climbing on it, as occurs in some primitive Old Word forms (Davis, 1964). Specialization evidences are

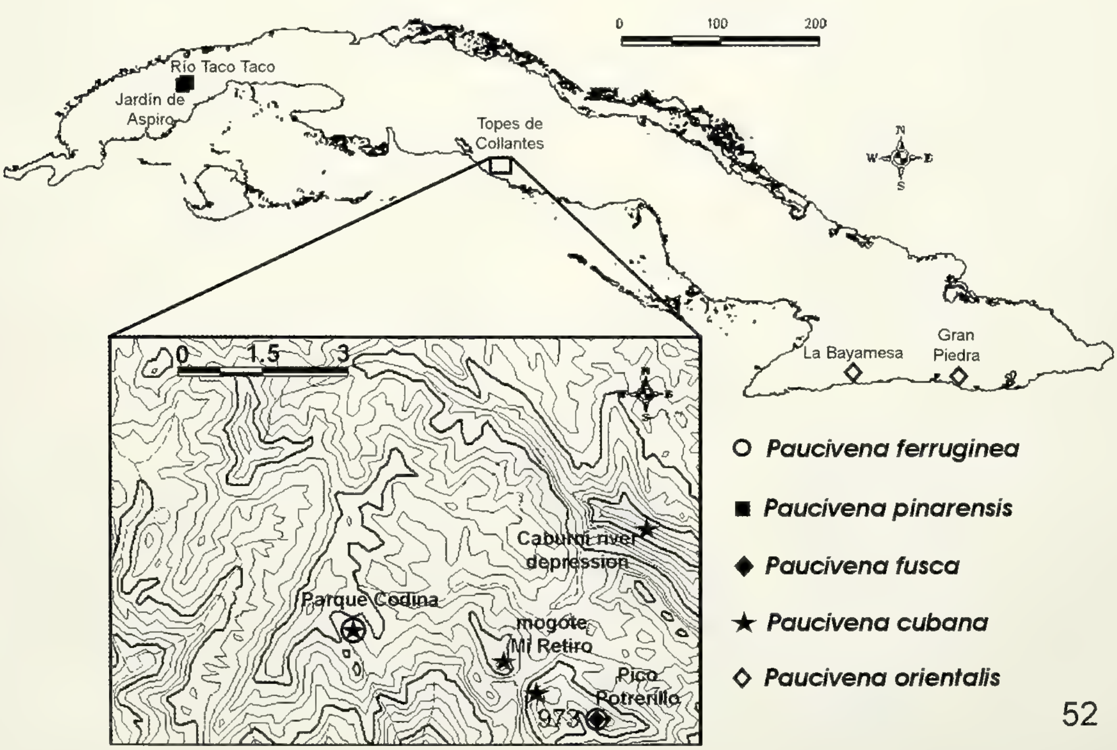


FIG. 52. Distribution of Cuban *Paucivena* spp. Scale bar in kilometers.

the reduced genitalia, the complete loss of antennae and wings and the slightly sclerotized body wall.

In the larvae, the color pattern of the head and thorax apparently lack diagnostic value, at least in Cuban species. In *P. ferruginea*, *P. cubana*, *P. pinarensis* and *P. orientalis* (the last two not described but observed during rearing), the pattern is white to greyish white with dark fuscous longitudinal bands. However, the abdominal integument is differently colored in *P. ferruginea* (dark brown) and *P. hispaniolae* and *P. cubana* (dirty white). Differences in chaetotaxy may be also used for species recognition.

Davis (1975) mentions that *P. hispaniolae* larvae feed on crustose lichens growing on the bark of an unidentified tree. Larvae of Cuban *Paucivena* feed on a wide variety of hosts including mosses, hepatics, lichens and detritus. All these food preferences have been observed before in the Psychidae (Davis, 1964; Hättenschwiler, 1985; Davis & Robinson, 1998) and perhaps explain in part genus diversification together with geographic isolation.

Paucivena appears to be well expanded on Cuba compared to other Antillean islands such as Hispaniola, Jamaica or Puerto Rico. However, this may due to lack of sampling on these islands. In Cuba, more collect effort on Psychidae is also needed. The Nipe-Sagua-Baracoa Mountains, in the northeast part of the island, and other habitats like coastal forests, ultramafic scrub, and white sand savannahs are yet unexplored.

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A REMARKABLE NEW RIODINID SPECIES, *STALACHTIS HALLOWEENI* (RIODINIDAE: STALACHTINI), FROM MOUNT AYANGANNA, GUYANA

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ABSTRACT. A new riodinid species, *Stalachtis halloweeni* Hall n. sp. (Stalachtini), is described from Mount Ayanganna, a tepui in western Guyana. A preliminary hypothesis of phylogenetic inter-relationships within the small genus *Stalachtis* Hübner is suggested, based on an informal study of external morphology and male genitalia. Three species groups are proposed, the *phlegia*, *calliope* and *euterpe* groups, and *S. halloweeni* is hypothesized to be sister to the remaining members of the *euterpe* group.

Additional key words: endemism, montane forest, morphology, South America

Situated in the Pakaraima Mountain Range of western Guyana, Mount Ayanganna (2042m) is one of the easternmost tepuis in the Guiana Shield. Like the other tepuis in western Guyana and eastern Venezuela, Mount Ayanganna consists of eroded sandstone remnants of the Roraima Formation (MacCulloch & Lathrop 2001), and its isolated high-elevation habitats harbor significant numbers of endemic plants and animals. During the last five years alone, several new endemic species of frogs, snakes and lizards have been described from Mount Ayanganna (MacCulloch & Lathrop 2001, 2002, 2004).

During the last ten years, there have been numerous Lepidoptera expeditions to the upland regions of western and southern Guyana (Fratello 1996, 2001, 2003, 2005). In 1999, accompanied by several US and Guyanan colleagues, S. Fratello led the first Lepidoptera collecting expedition to the upper slopes of Mount Ayanganna. Among the many new taxa of butterflies collected there were several new species of Riodinidae, including a new species of *Stalachtis* Hübner, 1818 (Stalachtini), although most of these species were represented by only a small number of female specimens. Fortunately, a second expedition to Mount Ayanganna in 2002, by a different team that included one of the 1999 Guyanan expedition members (R. Williams), produced additional *Stalachtis* specimens, including males.

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2

FIGS. 1–2. *Stalachtis halloweeni* adults (dorsal surface on left, ventral surface on right). 1. Holotype male, Mount Ayanganna, Guyana (USNM). 2. Paratype female, Mount Ayanganna, Guyana (USNM).

This new *Stalachtis* species is remarkable in several respects. It is the first new species to be described in this small, essentially South American genus of aposematic species for over 150 years, since Westwood (1851) described *S. magdalena*; it is the first known *Stalachtis* species to apparently occur exclusively in montane habitats; and its wing pattern differs substantially from that of its congeners. I herein describe this new *Stalachtis* species and attempt to establish its phylogenetic position within the genus by informally constructing a preliminary hypothesis of phylogenetic relationships for *Stalachtis* and proposing a new species-group classification.

Stalachtis halloweeni Hall, **new species**

(Figs. 1–2; 3; 4)

Description: MALE: Forewing length 29.5 mm. Forewing elongate, costal and distal margins approximately straight, four forewing radial veins, discal cell elongate; hindwing rounded and slightly elongate, hindwing veins Rs and M_1 stalked. *Dorsal surface*: Forewing ground color black, discal cell orange with some black scaling medially, broad orange rays in cells 2A and Cu_2 extending from (Cu_2) or near (2A) wing base to join submarginal band, orange rectangle at base of cell Cu_1, small orange spot at base of cell M_3, orange streaks in cells M_2 to R_{4+5} and R_2 immediately distal to discal cell end, decreasing in size from cell M_2 to cell R_2, broad submarginal orange band extending from costa to tornus, with an enlarged rectangular orange patch nearly encircling a black spot in cells M_3 and Cu_2, distal fringe black; hindwing ground color black, pale orange spot at wing base, a broad orange streak through discal cell and cells Cu_2 to M_1, and along anal margin, those in cells Cu_1 and M_3 shorter than

others and that in cell Cu_2 joining submarginal band, small distal orange spot in cell $Sc+R_1$, broad and uneven submarginal orange band extending from apex to tornus, distal fringe black. Ventral surface: Forewing differs from dorsal surface by having a small orange spot at costal wing base, only distal portion of orange streak present in cell 2A, orange streak in cell M_2 joining submarginal band, orange spot in cell R_2 replaced by a sparse scattering of whitish scales; hindwing differs by having a very narrow line of orange scaling at middle of costal margin, with a sparse scattering of whitish scales distally, a larger orange spot in cell $Sc+R_1$, a much larger and darker orange spot at wing base, and a sparse scattering of whitish scales along anal margin.

Head: First segment of labial palpi a mixture of black and white scaling, segment two black with a broad white lateral band and some white scaling ventrally, and third segment black; eyes bare and black, with a mixture of black and white scaling at margins; frons black, with white scaling laterally; antennae 60% of forewing length, segments black with white scaling at ventral base and narrow nudum region along inner ventral margin, clubs black.

Body: Dorsal surface of thorax black, tegula black with dark orange scaling at base, ventral surface of thorax black with a white band between legs and a large orange patch near base of forewing; abdomen black dorsally, with a broad orange band laterally, and white ventrally, with narrow black lines on either side (patterning virtually indiscernible in Fig. 1 due to a covering of mold), all legs black.

Genitalia (Fig. 3): Uncus in lateral view rectangular and vertically elongate, lateral "window" anterior to uncus very narrow, tegumen very narrow, with a triangular ventral margin; falces extremely long and ventrally directed, with a weakly bent "elbow"; vinculum narrow, anteriorly bowed, broadest medially and slightly posteriorly indented near ventral tip, with a posteriorly directed triangular section of sclerotized tissue at ventral margin and no anterior saccus; aedeagus narrow, convex and of medium length, gradually tapering to a slightly upturned and finely pointed tip, vesica exits along ventral margin of posterior third of aedeagus, cornutal patch consists of a short sclerotized rod with about six prominently curved and anteriorly directed spines densely positioned along all but its anterior tip, cornutal patch positioned about one third distance from posterior to anterior tip of aedeagus on uneverted vesica; pedicel in lateral view broad basally, becoming narrower in angular posterior section, pedicel joins aedeagus about one third distance from anterior to posterior tip; valvae in lateral view consist of a large rectangular basal section, a narrow, posteriorly elongate and round-tipped lower process, a slightly broader, more rectangular and posteriorly elongate upper process, with a posteriorly and upwardly curved, finely pointed terminal projection, a very broad and rounded inner process, slightly shorter than lower process, and a pointed transtilla of medium length extending posteriorly between pair of inner processes and across top of aedeagus; narrow tuft of long, posteriorly directed, pale brown setae around outer margin of genital capsule; eighth abdominal tergite and sternite rectangular.

FEMALE: Differs from male in following ways: Forewing length 28 mm. Distal forewing margin convex. *Wings*: Orange on both wings very slightly paler, medial black scaling in forewing discal cell more prominent, several forewing postdiscal orange spots do not extend as far proximally to cell bases, orange ray in ventral forewing cell M_2 does not distally join submarginal band.

Head: Second palpal segment slightly more elongate, third segment about twice as long; nudum region on antennal segments slightly larger.

Genitalia (Fig. 4): Corpus bursae somewhat narrow and elongate, with a pair of small, sclerotized, invaginated spine-like signa; ductus bursae consists of a large, creased, hardened swelling immediately posterior to corpus bursae containing about four pieces of rectangular sclerotization, a short membranous section posteriorly, then a long and twisted lightly sclerotized section, followed by a short, concave ventral section of sclerotization; membranous ductus seminalis exits ductus bursae dorsally immediately anterior to ventral section of sclerotization; ostium bursae in dorsal view consists of a small, round, sclerotized entrance hole, with a broad and prominently convex band

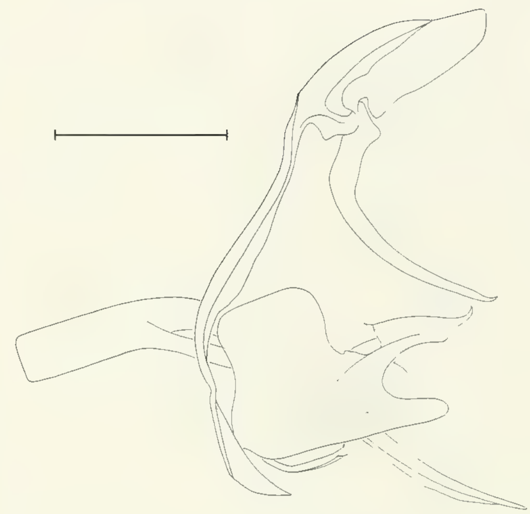

FIG. 3. Male genitalia of *Stalachtis halloweeni* holotype in lateral view. Scale bar = 1 mm.

of sclerotization dorsally curving anteriorly into an invaginated pouch below papillae anales that is membranous except for a broad, triangular, horizontal band of sclerotization along dorsal "roof" of pouch (perhaps a protected resting place for extremely long male genital falces during copulation); papillae anales proportionately small and round; very broad, semicircular tuft of long, posteriorly directed, pale brown setae around posterior margin of eighth tergite.

Types: *Holotype* ♂, GUYANA: *Cuyuni-Mazaruni*, Mount Ayanganna, 1120 m, 5°22.22'N 59°57.34'W, 12–16 Oct 2002 (R. Williams) (National Museum of Natural History, Smithsonian Institution, Washington, DC, USA [USNM]).

Paratypes: 1♂, 1♀, same data as holotype. 3♀, GUYANA: *Cuyuni-Mazaruni*, Mount Ayanganna, 4500–5500 ft, 5°24.1'N 59°57.4'W, 13–18 Apr 1999 (S. Fratello *et al.*) (USNM).

No additional specimens have been located in the major museums of Europe and North America (as listed in Hall 1999, 2005).

Etymology: The name is derived from the middle English word halloween, in reference to the fact that the wing pattern is composed of the traditional orange and black colors of Halloween, and is reminiscent of a carved pumpkin.

Systematic placement and diagnosis: *Stalachtis* (= *Nerias* Boisduval, 1836) is the sole genus currently treated in the tribe Stalachtini. The family-group name was proposed by Bates (1861), as a subfamily, for an undefined number of genera whose species possessed a "pupa not flattened beneath, secured rigidly by the tail in an inclined position, without girdle", a set of characters quickly discovered by Bates (1868: 368) himself not to be phylogenetically informative in the context of the higher classification of the Riodinidae. Stichel (1910–11) used the Stalachtini as a tribal name for the first time (as the Stalachtidi), and followed Bates (1868) in including only *Stalachtis* within it. Most recently, Harvey (1987) defined the monotypic Stalachtini by the presence of a tuft of long setae around

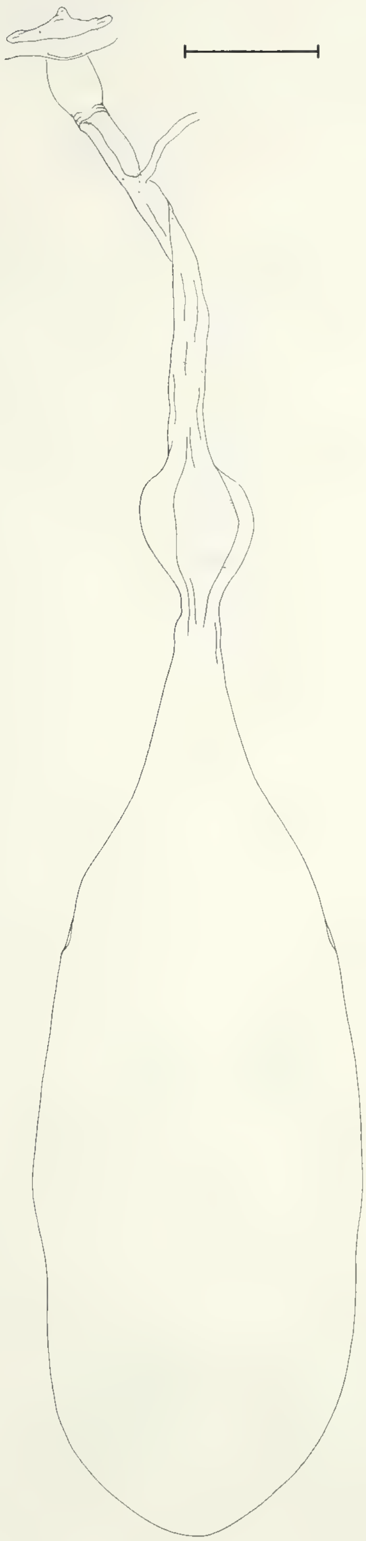

FIG. 4. Female genitalia of *Stalachtis halloweeni* paratype in dorsal view. Scale bar = 1 mm

the posterior margin of abdominal segment eight in males and, to a greater extent, females, and mentioned that its species are unusual in the Riodinidae in having hindwing veins Rs and M_1 stalked rather than arising separately from the discal cell end (Bates 1868; Stichel 1910–11). Additional unique characters that are universal within the Stalachtini include extremely long and weakly bent (i.e. ventrally directed) falces, a complex arrangement of inner valve processes, and a long straight comb of prominently curved, anteriorly directed spines on the aedeagal vesica in the male genitalia (Hall unpubl. data). The new *Stalachtis* species, *S. halloweeni*, possesses all of the above characters.

Traditionally, *Stalachtis* has been treated as containing eight species (e.g. Stichel 1910–11, 1930–31), although some authors have listed as many as ten species (D'Abrera 1994; Bridges 1994). However, the genus is now justifiably recognized to contain only six species (Callaghan & Lamas 2004). Hemming (1964, 1967) selected the type species of Hübner's (1818) *Stalachtis* to be *S. phaedusa* (Hübner, [1813]). It is worth mentioning that the name *Stalachtis funereus albulus* Lathy, 1958, which occasionally appears in the riodinid literature (e.g. Rebillard 1958; D'Abrera 1994; Bridges 1994), actually refers to a pericopine moth (Arctiidae) (Hall unpubl. data). Stichel (1910–11, 1930–31) divided *Stalachtis* into two sections, the "Adiorati" for *S. calliope* (Linnaeus, 1758) and *S. magdalena* Westwood, 1851, in one subgroup and *S. phlegia* (Cramer, 1779) (+ *S. susanna* (Fabricius, 1787)) and *S. euterpe* (Linnaeus, 1758) in another subgroup, and the "Diaphanes" for *S. phaedusa* (+ *S. zephyritis* (Dalman, 1823)) and *S. lineata* (Guérin-Méneville, [1844]). Based on a study of wing pattern and male genitalia characters in all six *Stalachtis* species, an alternative species-group classification and preliminary hypothesis of phylogenetic relationships for the genus is proposed here.

As *S. calliope*, *S. magdalena*, *S. euterpe*, *S. phaedusa* and *S. lineata* all share a pair of large, rounded, inner valve processes, with an elongate, pointed transtilla extending posteriorly between them and across the top of the aedeagus, *S. phlegia* is hypothesized to be sister to the remaining species in the genus. *Stalachtis phlegia* has a much smaller pair of inner valve processes, without the intervening transtilla, and has the least derived wing pattern, with a full complement of white basal, postdiscal and submarginal spots. *Stalachtis calliope* and *S. magdalena*, like *S. phlegia*, but unlike any other *Stalachtis* species, have a complete row of submarginal white spots on the forewing, an orange patch at the base of the dorsal forewing and hindwing,

and an entirely checkered black and white hindwing fringe. Their similar wing patterns, with mottled orange markings at the base of the forewing and parallel orange bands on the hindwing, shared possession of an upper valve process that is broadest medially (instead of basally in *S. phlegia* and distally in the remaining three species), and parapatric geographic ranges strongly suggest that they are sister species. *Stalachtis euterpe*, *S. phaedusa* and *S. lineata* appear to form a monophyletic group, as all three species share similarly positioned white wing markings that are consistently formed into rays instead of spots, the absence of an orange patch at the base of the dorsal forewing and hindwing, the absence of a complete row of submarginal white spots on the forewing, largely black wing fringes, and an upper valve process that is broadest distally. As *Stalachtis phaedusa* and *S. lineata* both have elongate hyaline rays on both wings they are probably sister species.

Stalachtis halloweeni appears to exhibit external pattern characters that are somewhat intermediate between those of members in the *calliope* and *euterpe* groups. It shares with the two *calliope* group species the presence of orange markings at the base of the dorsal forewing, and with *S. magdalena* the absence of a lateral white line above as well as below the lateral orange band on the abdomen. It shares with the three *euterpe* group species a similar pattern of rays at the base of the forewing and particularly the hindwing, even if these are orange instead of white, the absence of a complete row of submarginal white spots on the forewing, and black wing fringes. Based on the above characters, and the fact that *S. halloweeni* has the full complement of inner valve processes and an upper valve process that is broadest distally, this new species is tentatively suggested to be the most basal member of the *euterpe* group. The male genitalia of *Stalachtis* species are rather homogeneous, with the most significant interspecific variation exhibited by the upper and, to a lesser extent, lower valve processes. Although *S. halloweeni* appears to be most closely related to *S. euterpe*, its male genital valvae are probably most similar to those of *S. phaedusa*, but its upper valve process does not have such a prominent ventral protrusion at the posterior tip, and the posterior margin extends at about a 45° angle instead of vertically. Elsewhere in the *euterpe* group, *S. euterpe* can be characterized by its dorsal as well as ventral swelling to the distal tip of the upper valve process and atypically small and straight terminal projection, and *S. lineata* can be characterized by its broadly triangular instead of narrower rod-shaped lower valve process.

In conclusion, *Stalachtis* seems to be best divided into three species groups, the *phlegia* group for *S. phlegia*, the *calliope* group for *S. calliope* and *S. magdalena*, and the *euterpe* group for *S. halloweeni*, *S. euterpe*, *S. phaedusa* and *S. lineata*. Thus, only two of Stichel's (1910–11, 1930–31) three proposed species groups for *Stalachtis* appear to be monophyletic.

Biology: This new species appears to be restricted to lower montane forest habitats, where it is currently known from between about 1100 and 1700 m. Specifically, the type series was collected in wet, low (canopy approximately 10–15 m), evergreen high-tepui forest, a vegetation type that was described and illustrated by Maguire (1970), Huber *et al.* (1995) and MacCulloch & Lathrop (2001).

Steve Fratello (pers. comm.) observed approximately ten individuals of *S. halloweeni* on Mount Ayanganna, most of which were probably females, judging by the fact that all individuals captured were of that sex. Within the forest, these individuals consistently flew at about 5 to 7 m above the ground, although two individuals were observed flying only 2 to 3 m above the ground over a patch of low tepui scrub at 1700 m. Individuals were seen flying over a wide area from mid-morning to mid-afternoon, with a rather slow, steady flight, and were not observed alighting or resting. No other *Stalachtis* species were seen flying in the same habitats as *S. halloweeni*, but *S. phaedusa*, *S. calliope* and *S. euterpe* have been commonly collected in neighboring lowland areas of Guyana (Fratello pers. comm.).

Stalachtis is one of the most well known groups of aposematic riodinids (Seitz 1916–20; D'Abrera 1994). Given that the known caterpillars are gregarious and aposematic (Callaghan 1986), and members of at least some of the known foodplant families (e.g. Simaroubaceae) contain toxic phytochemicals (e.g. Moretti *et al.* 1982; Polonsky *et al.* 1984), it seems likely that some or all of the *Stalachtis* life stages are to some extent distasteful to predators, and adults may thus be predominantly Mullerian rather than Batesian mimics. However, I am not aware of any sympatric butterflies or moths that specifically closely resemble *S. halloweeni*.

Distribution: *Stalachtis halloweeni* is currently known only from the middle slopes of Mount Ayanganna, in the uplands of western Guyana. However, the geographic range of this species probably extends to neighboring highland areas in Guyana and extreme eastern Venezuela. There continues to be debate about whether most Guiana highland endemics are relicts of a widespread pantepui fauna or descendants of lowland ancestors (e.g. Myers & Donnelly 1996; MacCulloch & Lathrop 2001). Given that all six described *Stalachtis* species have entirely lowland distributions, the ancestor of *S. halloweeni*

presumably colonized Mount Ayanganna from the surrounding lowlands.

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A NEW SPECIES OF *AURATONOTA* (LEPIDOPTERA: TORTRICIDAE: CHLIDANOTINAE) FORMERLY CONFUSED WITH *A. HYDROGRAMMA* (MEYRICK)

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ABSTRACT. *Auratonota pharata*, new species, is described and illustrated from Costa Rica, Panama, Venezuela, and French Guiana. The species is most similar to *A. hydrogramma* (Meyrick), with which it formerly was confused. It can be distinguished superficially from the latter by the absence of the narrow pale curved band beyond the distal end of the discal cell of the forewing. The male genitalia of the new species differ by a slightly expanded, dorsally convex, and ventrally flattened distal portion of the uncus. The female genitalia possess numerous short curved bands of 5–6 microtrichia around a larger single seta set in a shallow pit on the surface of the middle of the papillae anales compared with the more semicircular bands of microtrichia nearly surrounding the seta in *A. hydrogramma*. A survey of wing coupling in numerous genera of Chlidanotini and Hilarographini revealed that the female frenulum consists of two bristles usually separated throughout their length in all representatives examined in these two tribes; three bristles are present in females of most other Tortricidae. This character state represents an additional putative synapomorphy uniting those two tribes.

RESUMEN. *Auratonota pharata*, especie nueva, es descrita e ilustrada de Costa Rica, Panama, Venezuela y Guyana Francesa. Este especie es mas similar a *A. hydrogramma* (Meyrick), con la cual ha sido con fundida. Puede ser identificada de una manera superficial de esta última por la ausencia de una banda curva fina clara detras de la portedistal de la celda discal de las alas anteriores. La genitalia del macho de la nueva especie puede ser distinguida por la presencia en la partediscal del uncus de una area ligeramente expandida, convexa dorsalmente y plana ventralmente. La genitalia de la hembra puede ser distinguida por la presencia de numerosas bandas curvas cortas de 5–6 espinas pequenas arriba de una sola seta en media superficie de los papillae anales en comparación con bandas más semicirculares de espinas pequeñas casi rodeando la seta en *A. hydrogramma*.

Additional key words: Systematics, genitalia, morphology, Costa Rica, Central America, Venezuela, French Guiana, inventory, Chlidanotini, frenulum

Auratonota Razowski is the largest and most diverse genus in Chlidanotini (Tortricidae: Chlidanotinae) with 30 described species (Razowski & Becker 2000, Brown 2005) and numerous undescribed species present in collections. The genus is restricted to the New World tropics, ranging from Mexico and the Caribbean (Cuba, Dominica) south through Brazil.

A previously undescribed species of *Auratonota* has been concealed in entomological collections for many years under the name *A. hydrogramma* (Meyrick). The similarity of the new species to *A. hydrogramma* in size, forewing pattern, and genitalia, along with their geographic sympatry, have combined to inhibit their recognition. The two species can be separated by a subtle feature of the forewing pattern, but recently discovered features of the male and female genitalia provide convincing evidence that they are indeed distinct and diagnosable. The purpose of this paper is to name, describe, and illustrate the new species. This work was stimulated, in part, by the desire to associate scientific names with morpho-species collected during the NSF-funded ALAS (Arthropods of La Selva, Costa Rica) project in order to more easily discuss differences and similarities among the tortricid faunas of transect sites (at different elevations) sampled over the course of the project (1993–2005).

Dissection methodology followed that presented in Brown and Powell (1991). Images of adults and genitalia were captured using a Microptics digital camera system and enhanced using Adobe Photoshop and Illustrator software. Terminology for genital structures follows Horak (1984). The following institutional abbreviations are used for the deposition of specimens examined: AMNH = American Museum of Natural History, New York, New York, U.S.A.; BMNH = The Natural History Museum, London, United Kingdom; INBio = Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica; UCB = Essig Museum of Entomology, University of California, Berkeley, USA; and USNM = National Museum of Natural History, Washington, D.C., U.S.A.

Auratonota pharata Brown, new species
(Figs. 2, 4, 5)

Diagnosis. Among described species of *Auratonota*, *A. pharata* is most similar to *A. hydrogramma* in forewing pattern, size, and genitalia. However, the latter is superficially distinguishable from all described congeners, including *A. pharata*, by the presence of a slender, pale, arched fascia in the subterminal region of the forewing that roughly parallels the apical half of the termen, intersecting the costa subapically (Fig. 1); the fascia is lacking in *A. pharata* (Fig. 2). The male genitalia of *A. pharata* can be distinguished from those of *A. hydrogramma* by the shape of the distal one-fourth of the uncus: attenuate and apically pointed in *A.*

hydrogramma (Fig. 3); slightly broadened, convex dorsally, and flattened ventrally in *A. pharata* (Fig. 4). The female genitalia are extremely similar in both but can be distinguished by a subtle feature of the papillae anales. In *A. pharata* microtrichia on the internal, middle portion of the papillae anales are arranged in short, slightly curved bands of 5–6 immediately dorso-posterad of a small, pale-colored pit from which arises a single larger seta (Fig. 5). In *A. hydrogramma* microtrichia are arranged in circular or semicircular bands of 8–9 nearly surrounding a more rounded pit (Fig. 6). *Auratonota pharata* also is similar superficially to *A. aporema* (Dognin), described from Colombia, but has a considerably smaller forewing length (mean 11.9 mm for *pharata* vs. 15.9 for *aporema*) and lacks the yellow-gold scaling of the forewing pattern elements of *A. aporema*; the latter feature is more characteristic of members of *Pseudocomotis* Brown (Chlidanotini), with which *A. aporema* is more similar superficially.

Description. *Head*: Vertex rough scaled, mostly pale cream with a few pale cream-brown scales; frons smooth scaled, pale cream white; labial paplus relatively slender, short, length (all segments combined) ca. 1.2 times horizontal diameter of compound eye, brown externally, pale cream on inner surface; antenna thickened, with setae extremely short, inconspicuous (typical of Chlidanotini). *Thorax*: Dorsum clothed in reddish-brown scales, anterior and posterior regions with considerable scattered white and pale brown scales; tegula pale brown, with variably expanded patch of long scales posteriorly, frequently expressed as an erect scale patch in both sexes. Legs unmodified; no hairpencil or secondary scale patches in male. Forewing length 11.5–12.9 mm ($\bar{x}$ = 11.9; n = 10) in male, 12.2–14.1 mm ($\bar{x}$ = 13.1; n = 2) in female; costa nearly straight, apex obtuse, termen slightly convex, rather oblique; ground color ferruginous, with light silvery-gray reticulations formed by irregular interrupted streaks on veins and a series of indistinct transverse fascia crossing them, scattered with iridescent green scales in interspaces (the green scales inconspicuous on flight worn specimens); basal portion from near base to ca. 0.66 distance to apex largely suffused with blackish brown between the reticulations; a small, ill-defined, irregularly-shaped, ferruginous spot near distal end of discal cell bordered basally by a narrow bluish silvery-gray line; termen uniform red-brown; fringe olive-ferruginous [lacking in most specimens examined]. Hindwing uniform dark brown, fringe concolorous; female frenulum with two bristles separated throughout their length. *Abdomen*: Dark brown. Male genitalia (Fig. 4; image of JWB slide 806, Costa Rica; n = 6) with uncus strong, long, mostly rod-shaped, slightly broader at base, curved near middle, slightly expanded in distal 0.25 with dorsum convex and venter flattened or weakly concave; socius moderately short, broad, subrectangular, clothed in long, fine scales; hami long, ca. 0.75 times length of uncus, weakly attenuate from base to tip, distal 0.1 bent dorsally; gnathos extremely reduced, lateral arms membranous, mesal portion inconspicuous; valva large, broad, expanding distally, distal 0.75 covered with fine, long setae, costa sclerotized; transtilla a simple, narrow band; juxta a broad, shield-like plate; saccus well developed, narrow, attenuate distally; aedeagus short, stout, mostly straight, slightly curved at phallobase, a tiny scobinate patch of small setae on each side near distal end, vesica with small linear patch of sclerotization. Female genitalia (Fig. 5; image of USNM slide 95264, Panama; n = 3) with papillae anales large, bearing numerous tiny, weakly curved lateral bands of spines in middle portion, which are situated immediately dorso-posterad of a small pale-colored pit from which a single seta arises; perimeter and basal portions of papillae anales with much larger setae arising from elongate, warty bases; sterigma simple, weakly sclerotized, ventral posterior edge of ostium with narrow row of 5–6 long setae on each side; ductus bursae broadest at ostium, narrowed at about 0.2 distance from ostium to corpus bursae, then nearly uniform in width to junction with corpus bursae; corpus bursae, large, pear-shaped sac, junction with ductus bursae slightly anterior of posteriormost end, signum a patch of 30–35 slender, slightly curved spines originating from sclerotized plate near middle of corpus; ductus seminalis from posteriormost end of corpus bursae near junction of corpus bursae and ductus bursae; a frail accessory bursae from a long, slender ductus originating just anterad of signum.

Holotype. Male: Costa Rica, Estacion Biologica La Selva, Puerto Viejo de Sarapiqui, 50–150 m, 10°26'N, 84°01W, 7 Feb 2002, Wagner, Rota & Kawahara (INBio).

Paratypes (24♂, 3♀). BRITISH GUIANA: Potaro River, Anundubaru, 2000', Jan 1928 (1♂) (AMNH). COSTA RICA: Heredia Province: Estacion Biologica La Selva, 10°26'N, 84°01'W, 50–150 m, Jan 1998 (1♀), INBio-OET, J. Powell (UCB), 8–25 Mar 1999 (1♂), 22–31 Mar 2001 (1♀), Wagner & Rota, 7 Feb 2002 (1♂), Wagner, Rota & Kawahara (INBio); Ciebo, 11 km ESE La Virgen, 250–350 m, 10°21'N, 84°01'W, 18 Mar 2004 (1♂) (INBio); 10 km SE La Virgen, 450–550 m, 10 20N, 84 05W, 17 Mar 2003 (2♂), 19 Mar 2003 (1♂), 22 Mar 2003 (1♂), INBio-OET-ALAS transect (INBio). Limón Province: Cerro Tortuguero, P.N. Tortuguero, 0–120 m, Oct 1989 (1♂), J. Solano (INBio), Jul 1991 (1♂), J. Solano (INBio), Jul 1993 (1♂), R. Delgado (INBio); Sector Cerro Cocori, Finca de E. Rojas, 150 m, Aug 1991 (2♂), E. Rojas (INBio). Unknown Province: Carchi [possibly Sarchi, Alajuela Province], [no date] (1♂), Wm. Schaus (USNM). FRENCH GUIANA: St. Jean, Maroni, [no date] (2♂), Wm. Schaus (USNM); Rio Maroni, [no date] (1♂), Le M[oult] (USNM). PANAMA: Canal Zone, Barro Colorado Island, 17 Sep 1941 (1♀), J. Zetek (USNM). VENEZUELA: Aragua: Rancho Grande, 1100 m, 16–23 Oct 1966 (3♂), 24–31 Oct 1966 (1♂), 1–5 Nov 1966 (1♂), S. S. & W. D. Duckworth (USNM), 15–21 Jun 1967 (1♂), 22–31 Aug 1967 (1♂), R. W. Poole (USNM).

Distribution and Biology. *Auratonota pharata* is recorded from Costa Rica, Panama, Venezuela, British Guiana, and French Guiana. Although it appears to be a species of the lowlands (i.e., below 500 m), it has been recorded on several occasions at Rancho Grande, Venezuela, at 1100 m and once in British Guiana from 660 m. During a multi-year survey in Costa Rica along an elevation transect, specimens were collected at 50–150 m (n = 4), 250–350 m (n = 1), and 450–550 m (n = 4), with none recorded from 1000, 1500, or 2000 m. Adults have been recorded in January through March, and June through November.

A female collected by J. Powell in January 1998 at La Selva, Costa Rica was confined in a plastic vial where it laid several huge, bulky eggs, 3.3 × 2.8 mm, ca. 10 times the size of comparable-sized tortricine females (J. Powell, pers. comm.). First instars likewise were large, 2.8–3.0 mm in length. Various leaves, synthetic diet, and raw carrot were offered to the larva; the last has been used successfully with other "borers" such as Hepialidae. The only feeding was by one larva on the carrot, and it ceased to feed before reaching second instar.

Etymology. The specific epithet is from the word "pharate," meaning cloaked or hidden.

Auratonota hydrogramma (Meyrick, 1912)

(Figs. 1, 3, 6)

Cnephasia hydrogramma Meyrick, 1912: 683.

Eulia hydrogramma: Clarke, 1958: 128.

Auratonota hydrogramma: Razowski, 1987: 62; Brown, 1990: 156; Powell *et al.* 1995: 151; Razowski & Becker, 2000: 1151; Brown, 2005: 144.

Auratonota hydrogramma was described from a single specimen from Dutch Guiana (= Surinam) (BMNH). The adult and male genitalia of the holotype are figured by Clarke (1958); Razowski & Becker (2000) provided a color illustration of an adult and line drawings of the male and female genitalia. Based on material in several museum collections (AMNH, BMNH, INBio, USNM), it has been recorded from Costa Rica, Panama, Colombia, French Guiana, British Guiana, and Ecuador and at many of the same localities as *A. pharata* (e.g., Costa Rica, Estacion Biologica La Selva; Panama, Barro Colorado Island; French Guiana, St. Jean, Rio Maroni). Razowski & Becker (2000) reported it from Brazil. As is the case in *A. pharata*, *A. hydrogramma* appears to be a species of the lowlands, rarely collected above 600 m. During the multiple-year transect surveys of the ALAS project in Costa Rica (1993–2005), *A. hydrogramma* was collected only at the 50–150 m elevation site.

Auratonota hydrogramma can be distinguished superficially from all other congeners by the presence of a narrow, curved, pale fascia in the apical region of the forewing. The male genitalia (Fig. 3, image of USNM slide 84889, Panama; n = 6) are slightly smaller and have a slightly broader base of the saccus than those of *A. pharata*; but the most conspicuous feature that distinguishes the two species is the pointed tip of the uncus of *A. hydrogramma*. The papillae anales (Fig. 6, image of JWB slide 745, Costa Rica; n = 2) of *A. hydrogramma* also have the tiny curved bands of microtrichia described above for *A. pharata*, but in *A. hydrogramma* the bands are more semicircular and nearly surround a rounded, pale-colored pit. Even though only two females of each species were examined, these differences appear to be consistent.

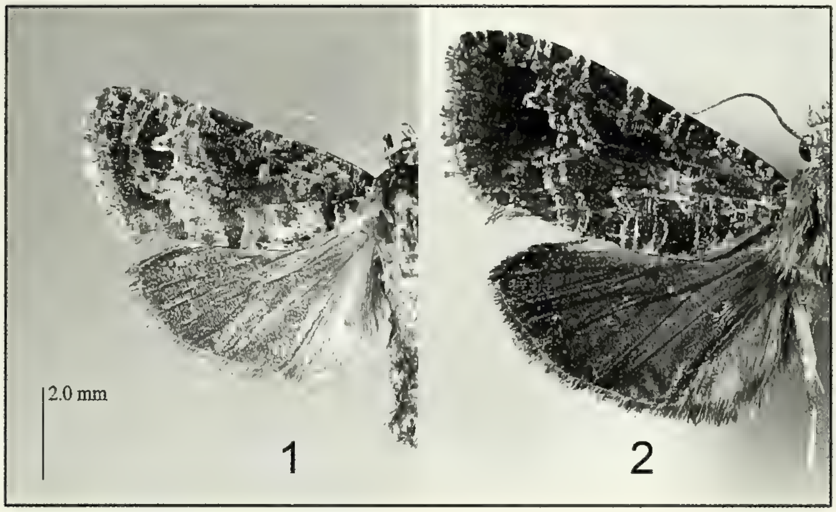
Holotype ♂, Dutch Guiana [Surinam], Paramaribo, Aug 1892 (BMNH).

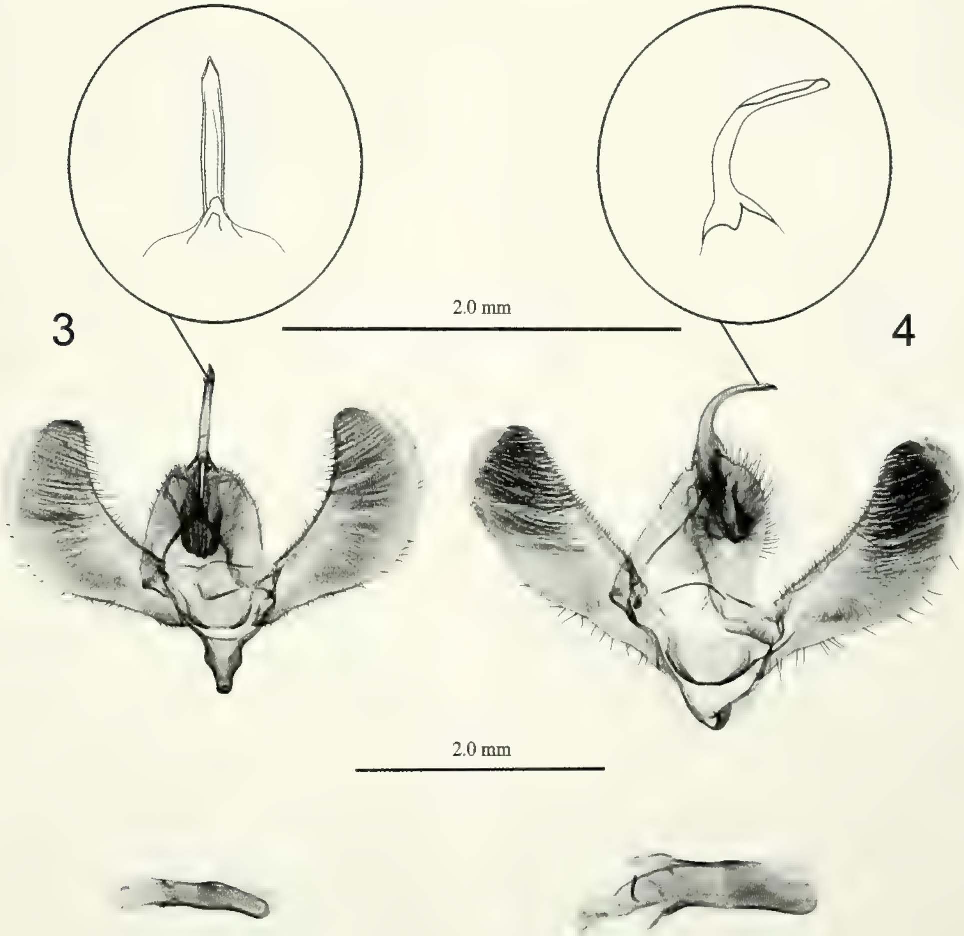
Additional specimens examined: BRITISH GUIANA: Bartica District, Kartabo, 2 Apr 1926 (1♂) (AMNH). COLOMBIA: Dept. Valle, Anchicaya, 600 m, 76° 53'W, 3° 33'N, 20–24 Jan 1992 (1♂), J. B. Sullivan (USNM). COSTA RICA: Cartago Province: Turrialba, 13–17 Mar 1965 (1♀), S. S. & W. D. Duckworth (USNM). Heredia Province: Finca La Selva, Puerto Viejo de Sarapiqui, 50 m, 6–9 Mar 1985 (1♂), D. Janzen & W. Hallwachs (USNM); La Selva Biological Station, 10°26'N, 84°01'W, Jan 1998, INBio-OET, J. Powell (UCB),18 Feb 2003 (1♀), 27 Feb 2003 (1♂), 28 Feb 2003 (1♂), D. Wagner (INBio); Estacion Magassay, P.N. Braulio Carrillo, 200 m, Feb 1991 (1♀), M. Barrelier. Limón Province: Rio Sardinas, R.N.F.S. Barra del Colorado, 18–29 Feb 1993 (1♂), F. Araya; 30 km N Cariari, Sector Cocori, 100 m, Dec 1993 (1♂), Nov 1993 (1♂), E. Rojas; Finca de E. Rojas, Sector Cerro Cocori, 150 m, Sep 1993 (1♂), Apr 1991 (1♂), Aug 1991 (1♂), E. Rojas; Cerro Tortuguero, P.N. Tortuguero, 100 m, Apr 1989 (1♂), R. Aguilar & J. Solano, Jan 1993 (1♂), R. Delgado. Puntarenas Province: Estacion Esquinas, Peninsula de Oso, 0–200 m, Feb 1993 (4♂), Sep 1993 (2♂), Oct 1993 (1♂), Aug 1993 (1♂, 1♀), May 1993 (1♂), J. Quesada, Feb 1993 (2♂), Mar 1994 (1♂), 1 Apr 1993 (1♂) M. Segura, Jan 1993 (1♂), G. Fonseca; Est. Esquinas, Peninsula de Osa, 200 m, Aug 1993 (1♂), J. Quesada (INBio); Bosque Esquinas, Peninsula de Oso, 200 m, Jan 1993 (1♂), Apr 1993 (2♂), J. Quesada; Mar 1994 (1♂), M. Segura; Albergue Cerro de Oro, 150 m, 30 Aug 1995 (1♂), L. Angulo; Estacion Sirena, P.N. Corcovado, 0–100 m, Jan 1993 (1♂), Nov 1989 (1♂), Jul 1991 (1♂), Jun 1990 (1♂), Jun 1993 (1♂), G. Fonseca, 1–19 Aug 1980 (1♂), 10–12 Aug 1980 (2♂), 5–11 Jan 1981 (1♂), D. Janzen & W. Hallwachs, Aug 1991 (2♂), J. C. Saborio; Golfito. R.V.S. Golfito, Sector El Tajo, 15 May 2002 (1♂), M. Moraga; Rancho Quemado, Peninsula de Oso, 200 m, Oct 1991 (1♂), Oct 1991 (1♂), Nov 1990 (1♂), F. Quesada; Cerro de Oro, 200 m, 26–30 May 1995 (1♂), E. Phillips (all INBio). Unknown Province: Sixola River, [no date] (1♂) (USNM). ECUADOR: Pichincha, Tinalandia, 16 km E Santo Domingo de los Colorados, 600 m, 5–11 May 1990 (1♂), R. Leuschner (USNM). FRENCH GUIANA: St. Jean, Maroni, [no date] (4♂), Wm. Schaus (USNM), [no month] 1926 (♂, paralectotype), LeM[oult] (USNM); Piste de la Montagne des Singes, km 10, 5°05'N, 52°42'W, 8 Jan 1985 (1♂), J.-F. Landry (USNM); Godebert-Maroni, [no date] (1♂), Collection Le Moult (USNM); Saint-Jean du Maroni, [no date] (1♀), Janvier (USNM). PANAMA: Canal Zone: Barro Colorado Island, 1–9 May 1964 (5♂), 25–28 Mar 1965 (2♂), W. D. & S. S. Duckworth (USNM), 11 Mar 1941 (1♂), J. Zetek, [no date] (♂), J. Zetek (USNM), 21 Mar 1933 (1♂) (AMNH), 19–22 Jul 1951 (1♂), R. M. Laughlin (AMNH), 14 Feb 1936 (1♂) (AMNH); Navy Res. nr. Gamboa, 29 Mar 1965 (1♂), S. S. & W. D. Duckworth (USNM).

DISCUSSION

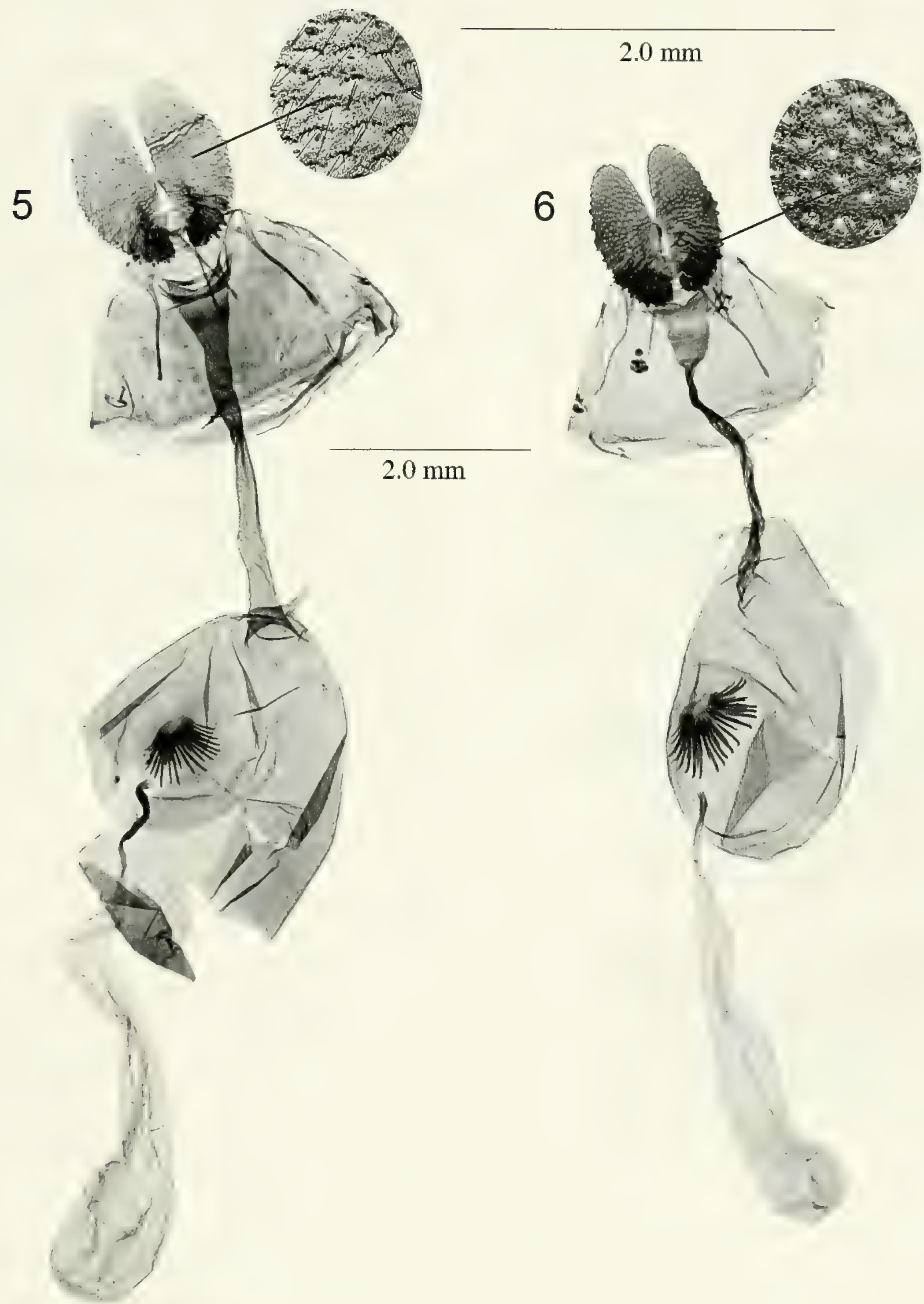
In most tortricids, the setae of the papillae anales arise from variably sized, papillose protuberances. In *A. hydrogramma* and *A. pharata* these protuberances are present only around the perimeter of the papillae anales, with most of the papillae anales bearing short, thin setae from weakly depressed pits bordered by a straight or curved row of microtrichia. This unusual arrangement of setae also is present in *A. petalocrossa* and is suspected to occur in *A. aporema*—these four species are all similar in size, forewing markings, and structures of the male genitalia. These features are easily observed using a dissecting microscope because of the large size of the moths. In *Auratonota dominica* Brown there is a similar configuration of setae but at a much smaller scale, requiring observation using a compound scope. Similar arrangements of setae appear to be lacking in other Chlidanotini genera examined, leading to the possibility that it is a feature unique to *Auratonota*.

The structure of the frenulum in the female of *A. pharata*, with two distinct bristles clearly separated at their base, is somewhat unusual in Tortricidae where the female frenulum typically consists of three bristles, usually coalesced basally. A two-bristled frenulum was hypothesized by Komai (1999) to represent a syanpomorphy for *Strophedra* Herrich-Schäffer and





FIGS. 1-2. Adults of *Auratonota*. 1, *A. hydrogramma*, 2, *A. pharata*.
FIGS. 3-4. Male genitalia of *Auratonota*, with valve spread and aedeagus remove (inset of uncus). 3, *A. hydrogramma*, 4, *A. pharata*.



FIGS. 5-6. Female genitalia of *Auratonota*, with inset of details of papillae anales. 5, *A. pharata*, 6, *A. hydrogramma*.

Andrioplecta Obraztsov (Grapholitini), and more recently Brown and Baixeras (2006) discussed its distribution among species of several genera of Grapholitini. However, to my knowledge it previously has not been reported in Chlidanotinae. A survey of various (but not all) genera within that subfamily revealed that all Hilarographini and Chlidanotini examined have a female frenulum that consists of two bristles, potentially representing an additional synapomorphy for that putative sister-group pair. Its distribution is less consistent within Polyorthini where females of *Polyortha* Dognin, *Ardeutica* Meyrick, *Lopharcha* Diakonoff, and *Cnephasitis* Razowski have two bristles and those of *Isotrias* Meyrick, *Olindia* Guenée, *Chlorortha* Razowski, *Ebodina* Diakonoff, and *Lypothora* Razowski have three; it is variable among females of *Histura* Razowski.

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A REVISION OF *PSOLOPTERA* BUTLER, INCLUDING A REDESCRIPTION OF ITS KNOWN SPECIES (ARCTIIDAE: ARCTIINAE: EUCHROMIINI)

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ABSTRACT. *Psoloptera* Butler, a genus of three species within Euchromiini, was previously described based on wing venation and overall appearance, resulting in a polyphyletic assemblage. Here, species of *Psoloptera* are redescribed and illustrated. One species, *P. aurifera* (Herrich-Schäffer), is transferred to *Calonotos* Hübner as a **new combination**. Comparisons of male and female genitalia of *Psoloptera* with other historically associated genera refute previous hypotheses on euchromiine relationships.

Additional key words: Neotropical fauna, taxonomy, mimicry

The tribe Euchromiini (Lepidoptera: Arctiidae: Arctiinae) consists of highly specialized mimics of Hymenoptera, Diptera, and Coleoptera. This specialized mimicry has confounded efforts to classify these animals; distantly related species may mimic the same model, resulting in a convergence in appearance. Historically, classifications were formed based on overall wing venation and similar coloration. This practice often results in polyphyletic genera. One such genus is *Psoloptera* Butler (Figs. 1–3).

Butler (1876) erected *Psoloptera*, and originally placed two species in the genus, *P. thoracia* (Walker) and *P. leucosticta* (Hübner). Later, Schaus (1894) described *P. basifulva*, citing that it was allied to *P. thoracia* (Walker), the type of *Psoloptera*. Hampson (1898) placed *P. aurifera* (Herrich-Schäffer) in *Psoloptera* because of similar overall appearance and wing venation.

Butler (1876) placed *Psoloptera* in the subfamily Euchromiinae (= Euchromiini of Jacobson & Weller 2002), and stated that it was closely allied to *Calonotos* Hübner and *Amycles* Herrich-Schäffer (= *Pompiliodes* Hampson 1898; = *Sphecosoma* Simmons & Weller in press), but distinct because of its plumose antennae and different hindwing venation. Hampson (1898), in his phylogeny of the Syntominae, placed *Psoloptera* as ancestral to *Metaloba* Hampson, and sister to *Calonotos*, *Chrysocale* Walker, *Micragyrta* Butler, *Mystrocneme* Herrich-Schäffer, *Orcynia* Walker, *Paramya* Druce (= *Methysia* Butler; Simmons & Weller in press), *Saurita* Herrich-Schäffer, and *Scena* Walker. Forbes (1939a) allied *Psoloptera* to *Saurita* based on wing venation, and noted that the genera differed in the branching of the radial veins. Though a consensus of these views indicates a close relationship with *Calonotos*, this assertion has never been examined using any characters other than external features.

This paper redescribes *Psoloptera* and revises its composition by transferring one species to *Calonotos*. The individual species are diagnosed and figured. The genitalia of both sexes of all *Psoloptera* species are figured for the first time here as well. Relationships of *Psoloptera* and other euchromiines are discussed.

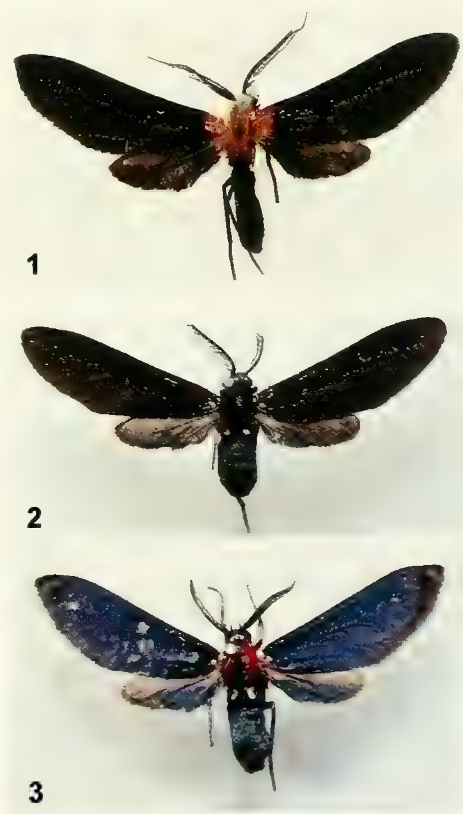

FIG. 1. Male *P. basifulva* Schaus, type specimen (USNM). **FIG. 2**. Adult *P. leucosticta* (Hübner), lectotype specimen (USNM). **FIG. 3**. Male *P. thoracia* (Walker), type specimen (BMNH).

MATERIALS AND METHODS

Standard genitalic and whole-body dissections were performed (Winter 2000). Bodies were softened in warm 10% KOH for 5–15 minutes and then cleaned (scales and viscera removed) in several rinses of 30–40%

ethanol. Structures were stained with chlorazole black E (Sigma, St. Louis, MO) dissolved in distilled water (saturated). Specimens were viewed in 30–40% ethanol. Wings were bleached and then neutralized with dilute acetic acid. They were then rinsed in distilled water, and stained overnight with Eosin Y (1% in distilled water; Fisher Scientific, Pittsburgh, PA). Permanent slide mounts of wings, abdominal pelts, appendages, genitalia and thoraces were made with Euparol (Bioquip, Rancho Dominguez, CA).

Male-female pairs of each species of *Psoloptera* (sensu Zerny 1912) were dissected to describe genitalia. These species included *P. thoracia* (Walker), *P. aurifera* (Herrich-Schäffer), *P. basifulva* Schaus, and *P. leucosticta* Hübner. Camera lucida drawings were made from these preparations. Forewing measurements were made from specimens representing each species of *Psoloptera*. Type specimens for *P. aurifera* (BMNH), *P. basifulva* (USNM), and *P. thoracia* (BMNH) were examined to verify species identifications.

Genera previously associated with *Psoloptera* were examined to identify putative sister taxa. Male and female genitalia were examined for *Calonotos phlegmon* (Cramer), *Chrysocale principalis* (Walker), *Metaloba argante* (Druce), *Methysia notabilis* (Walker), *Orcynia calcarata* Walker, *Saurita cassandra* (L.), *Scena styx* (Walker), and *Sphecosoma aliena* (Walker).

Terminology for abdominal and genital morphology follows Klots (1970) and Forbes (1939b). Collections consulted include BMNH, the Natural History Museum, London (M. Scoble), and NMNH, National Museum of Natural History, Smithsonian Institution, Washington, D.C. (D. Harvey).

RESULTS AND DISCUSSION

Species composition. *Psoloptera basifulva*, *P. leucosticta*, and *P. thoracia* are medium-sized black moths with lateral white spots on the first abdominal segment, which may mimic a wasp waist (Weller *et al.* 2000). Upon examination of *Psoloptera* species *sensu* Hampson, I found that *P. basifulva*, *P. leucosticta*, and *P. thoracia* can be distinguished from *P. aurifera* by both genitalic and nongenitalic characters. *Psoloptera aurifera* is colored metallic green and is larger than the other species of *Psoloptera*. Further, *P. aurifera* males have an enlarged juxta bearing large spines, bilobed valves, and a trilobed uncus (Fig. 4). These characters are not shared with the other members of *Psoloptera* (see following species descriptions), but are diagnostic for *Calonotos* males. Based on these observations, I propose the following change:

P. aurifera (Herrich-Schäffer), 1854 = *Calonotos aurifera* (Herrich-Schäffer), **new combination**

Phylogenetic placement. In Euchromiini, male genitalia are useful for assigning species to genera, grouping genera, and for verification of tribal affiliation. *Psoloptera* shares genital features with some other euchromiines: projections on the tegumen, slightly bilobed valves, and enlarged juxta. *Calonotos phlegmon*, *Chrysocale principalis*, and *Metaloba argante* share an enlarged juxta with spines, as in Fig. 4. This character is also present in *Macrocneme* Hübner and certainly represents a synapomorphy for this group of genera (Deitz 1994). *Methysia notabilis* appears to have highly specialized genitalia with trilobed valves and a spirelike juxta (figured in Simmons & Weller in press). Males of *Saurita cassandra*, *Scena styx*, and *Sphecosoma aliena* do not have genitalia similar to *Psoloptera* males (not figured). The valves of *Orcynia* are bilobed, while those of *Psoloptera* are unilobed; however, *Orcynia calcarata* has projections on the tegumen similar to those of *Psoloptera* and its juxta is slightly butterfly-shaped.

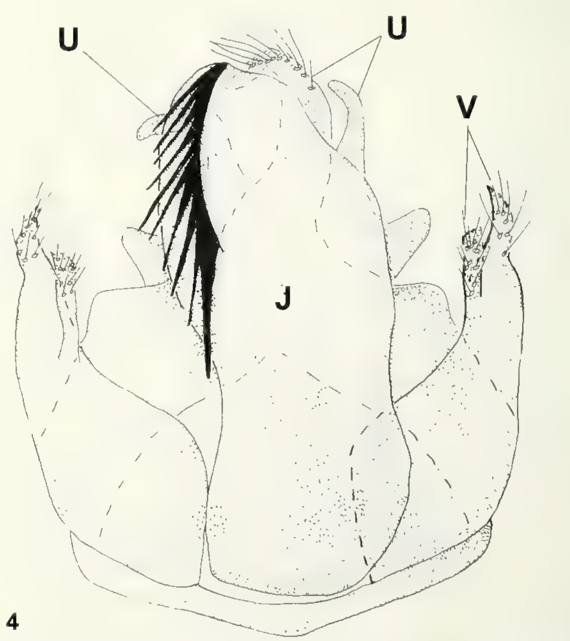

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FIG. 4. *Calonotos aurifera* (Herrich-Schäffer), male genitalia. J = juxta, U = uncus, V = valve.

As in other Lepidoptera, the female genitalia of Euchromiini tend to be more conserved than those of the males. *Psoloptera* females have genitalia with two signa placed opposite each other on the corpus bursae and an accessory bursa originating from the ductus bursae (Figs. 8, 11, 14). These traits are shared with other euchromiines examined here including *Calonotos phlegmon*, *Chrysocale principalis*, *Metaloba argante*, and *Saurita cassandra*. Based on these observations, Butler's (1876) placement of *Psoloptera* in Euchromiini

is justified. *Metaloba* seems to be related to *Calonotos*, *Chrysocale*, and *Macrocneme* because of the presence of a knob-shaped projection on the antevagellar plate, which is not found in *Psoloptera*. The sister taxon of *Psoloptera* is probably not *Saurita*, as proposed by Forbes (1939a) or *Calonotos* (Butler 1876, Hampson 1898). Female *Orcynia* possess a ridged bursae, like that of *P. basifulva* (Fig. 8), but the signa differ. Although the male and female genitalia are not identical to those of *Psoloptera*, *Orcynia* seems to be the most likely candidate for the sister taxon. This relationship remains open to further exploration with other data, such as molecular or larval characters.

Taxonomy. Here, I redescribe *Psoloptera* and provide illustrations of the habitus, wing venation, and male and female genitalia of its three species.

Psoloptera Butler, 1876

Psoloptera Butler, 1876: 369.

Type: *Euchromia thoracia* Walker 1854: 243, by original designation.

Diagnosis. This genus superficially resembles many other euchromiine and ctenuchine genera (Figs. 1–3). The male genitalia of *Psoloptera*, especially the ornamented, V- or butterfly-shaped juxta is distinctive within Ctenuchini and Euchromiini. The highly sclerotized, curved uncus is also unique to *Psoloptera*.

Adult habitus (Figs. 1–3). Wings entirely black, or with scarlet at the base. Male forewing length 12–17 mm (average = 14.5 mm, SD = 1.2 mm, n = 20); female forewing length 12–17 mm (average = 14.9 mm, SD = 1.5 mm, n = 11). Antennae black. Ground color of head and thorax black or red; abdomen black with paired lateral spots on first abdominal segment.

Head and thorax. Antennae biserrate and ciliate in males; filiform and ciliate in females; ocelli present with melanized outer ring. Proboscis longer than head. Epiphyses and tibial spurs short and smooth. Tarsal claws simple.

Wings. **Forewing venation** (Fig. 5A): Sc sinuous, extending 3/4 of the costa. R_1 and R_2 branched, arising from discal cell. R_{3-5} stalked with R_5 arising closer to cell than R_{3-4}. M_1 arising from the cell; M_2 arising from the cell medially between M_1 and M_3. M_3 arising from the base of the cell. CuA_1 and CuA_2 widely separated; A_1 present. Hindwing venation (Fig. 5B): Sc + R_1 absent. Rs and M_1 connate. Discal cell cross vein asymmetrical, V-shaped. M_{2+3} fused. CuA_1 and CuA_2 stalked, branching close to wing margin. A_1 and A_2 present.

Abdomen. In both sexes, second sternite with short, stubby apodemes. Structural modifications for wasp waist absent (Weller *et al.* 2000). Male lacking androconia.

Genitalia. **Males** (Figs. 6, 7, 9, 10, 12, 13): **Tegumen** bearing curved projections (TP) (Figs. 6, 9, 12), one on either side of uncus; uncus strongly sclerotized, hooked, setose. **Valve** (V) setose, spindlelike or slightly bilobed. **Juxta** (J) enlarged, V- or butterfly-shaped. **Aedagus** with sclerotized vesicular region (SP) (Fig. 7), cornuti (C) or both (Fig. 10), depending on the species.

Females (Figs. 8, 11, 14): **Papillae anales** (PA) laterally flattened; membrane surrounding ovipore folded; posterior apophyses (PP) long and narrow; anterior apophyses (AP) long and narrow or reduced and thickened; dorsal pheromone glands reduced. **Seventh sternite** (VII) unmodified; antevagellar plate unmodified or bearing crescent-like, heavily sclerotized lip; ostium bursae symmetrical or assymetrical. **Ductus bursae** (DB) short, membranous. **Corpus bursae** (CB) with two patches of spinose signa (S) located opposite one another.

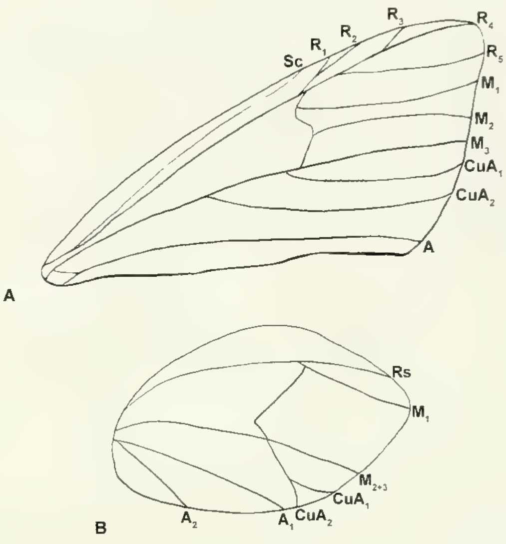


FIG. 5. Wing venation of *Psoloptera* Butler. A. Forewing, B. Hindwing. A = anal vein, CuA = cubital vein, M = medial vein, R = radial vein, Rs = radial sector, Sc = subcosta, 1-5 = vein number.

Appendix bursa (AB) from ductus bursae, irregular in shape, lacking ornamentation. **Ductus seminalis** (DS) from appendix bursa.

Discussion. Species of *Psoloptera* are easily distinguished from each other by habitus and male and female genitalia. The larval host plants and stages are not known. Tymbal organs are present, indicating that ultrasound is utilized for either defense or intraspecific communication; they do not appear to be sexually dimorphic.

Psoloptera basifulva Schaus, 1894
(Figs. 1, 6, 7, 8)

Psoloptera basifulva Schaus, 1894. Proc. Zool. Soc. Lond. 1894: 225.

Psoloptera thoracia Druce, 1884. Biol. Centr.-Am., Het. 1: 46, preoccupied by *Psoloptera thoracia* Walker (1854).

Diagnosis. Though *P. basifulva* resembles *P. thoracia*, *P. basifulva* has orange-red patches at the base of the fore- and hindwings (Fig. 1). These patches are lacking in *P. thoracia* (Fig. 3). *Psoloptera basifulva* also has an orange-red thorax and head; the head and thorax are black in *P. leucosticta* (Fig. 2).

Description. Medium-sized, black moths that have red heads and thoraces (Fig. 1).

Male. *Head* Red; antenna black, biserrate; frons and labial palpus black.

Thorax. Patagium, meso-, metathorax orange-red; fore, mid, and

hindlegs black with white spots on coxae and femur; tarsi black.

Wings. Forewing. Length = 14–16 mm (average = 15 mm, SD = 1 mm, n = 3). Black with basal scarlet area. Hindwing. Black, costal area slightly hyaline, basal scarlet area present.

Abdomen. Black with white spots on the first abdominal segment.

Genitalia (Figs. 6 & 7). Tegumen heavily sclerotized, bearing spirelike projections (TP), one on each side of uncus; uncus curved, setose; saccus square-shaped; valve unilobed, spatulate, setose; juxta enlarged, butterfly-shaped; base of phallus rounded; vesica with sclerotized area.

Female. As in male, except antennae filiform and ciliate; forewing length = 12–17 mm (average = 14.4 mm, SD = 1.7, *n* = 7).

Genitalia (Fig. 8). Papillae anales, posterior apophyses unmodified; anterior apophyses greatly reduced, nublike; S7 unmodified; antevagellar plate U-shaped, highly sclerotized; asymmetrical; ductus bursae sclerotized tube; corpus bursae membranous, slightly ridged, bearing two patches of signa near accessory bursa; ductus seminalis from middle of accessory bursa.

Type material. *Psoloptera basifulva* Schaus. The holotype male (USNM) is labeled: Peru; 520; not [? text unreadable]; Collection Wm Schaus. Type locality: Peru (Fig. 1).

Psoloptera thoracia Druce. The holotype male (BMNH) is labeled: Panama: Chiriqui; Godman-Salvin Coll. Type locality: Panama.

Specimens examined. BRAZIL: Amazones: Villa Franca (BMNH: 2♂, 2♀); **BRITISH HONDURAS: Punta Gorda** (BMNH: 7♂, 5♀); **No Data** (BMNH: 1♀); **COSTA RICA**: **Guapiles** (USNM: 1♀); **San Mateo** (BMNH: 1♀), **Tuis** (USNM: 1♂); **GUATEMALA: Cayuga** (USNM: 8♂, 6♀; BMNH: 2♂, 2♀); **HONDURAS: Cambre** (BMNH: 3♂, 1♀); **MEXICO: Tabasco** (BMNH: 1♂, 2♀): Teapa (USNM: 1♀); **PANAMA: Bugaba** (BMNH: 2♂); **Chiriqui** (BMNH: 1♂); **NICARAGUA: No Data**: Mobile 752 on a ship (USNM: 1♀); **PERU: No Data** (USNM: 1♀); **VENEZUELA: Palma Sola** (BMNH: 1♂); **NO DATA**: (USNM: 2♂).

Psoloptera leucosticta (Hübner, 1827)
(Figs. 2, 9, 10, 11)

Glaucopis leucosticta Hübner, 1827. Samml. Exot. Schmett. 1: t. 162.

Psoloptera leucosticta (Hübner) Hampson 1898. Cat. Lep. Phal. 1: 285.

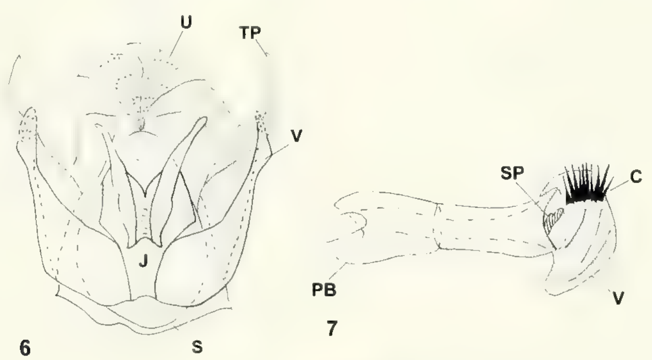
Diagnosis. *Psoloptera leucosticta*, unlike its congeners, does not have any red markings on its head or thorax (Fig. 2).

Description. Medium-sized, black to purplish-black moths (Fig. 2).

Male. *Head*. Black; antenna black, biserrate and ciliate; palpus black; vertex and frons with white spots.

Thorax. Patagium black with lateral white spot; mesothorax black; metathorax black; fore, mid, and hind legs black with white spots on the coxa.

Wings. Forewing. Length = 13–16 mm (average = 14.4 mm, SD = 1.1 mm, *n* = 8). Black, with two white spots at base. Hindwing.



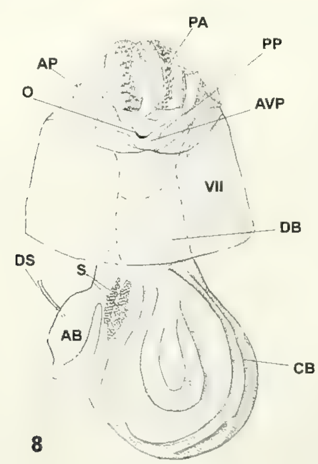


FIG. 6. *Psoloptera basifulva* Schaus, male genitalia, ventral view. J = juxta, S = saccus, TP = tegumenal process, U = uncus, V = valve. **FIG. 7**. *Psoloptera basifulva* Schaus, aedagus, lateral view. PB = phallic base, SP = sclerotized plate, V = vesica. **FIG. 8**. *Psoloptera basifulva* Schaus, female genitalia, ventral view. VII = seventh sternite, AB = accessory bursa, AP = anterior apophysis, AVP = antevagellar plate, CB = corpus bursae, DB = ductus bursae, DS = ductus seminalis, O = ostium, PA = papillae anales, PP = posterior apophysis, S = signa.

Ground color black; lighter shade of black in costal area.

Abdomen. Black. Dorsal lateral white spots on first abdominal segment. Medial white, faint patch on venter of first three abdominal segments.

Genitalia (Figs. 9 & 10). Tegumen heavily sclerotized, bearing spirelike projections, one on each side of uncus; uncus curved, setose; saccus rounded; valve terminating in blunt projection, setose; juxta elongate and narrow, V-shaped; phallus blunt at base; vesica bearing single patch of large cornuti apically.

Female. As in male, except antennae filiform and ciliate; forewing length = 15–16 mm (average = 15.5 mm, SD = 0.7 mm, *n* = 2).

Genitalia (Fig. 11). Papillae anales, posterior and anterior apophyses unmodified; S8 unmodified; antevagellar plate asymmetrical, without ornamentation; ductus bursae membranous; corpus bursae membranous, bearing two patches of signa; accessory bursa membranous, from ductus bursae; ductus seminalis from accessory bursa.

Type material. The type of *Glaucopis leucosticta* Hübner is apparently lost. Type locality: Venezuela. The lectotype male (USNM, here designated) is labeled: 60 m. up Maroni River, *Psoloptera leucosticta* Hbn. from BM, Collection Wm Schaus. The lectotype is designated to ensure nomenclatural stability in this genus.

Specimens examined. BRAZIL: Cayenne (USNM: 1♀); **BRITISH GUIANA: Rio Potaro**, Tumatumari (USNM: 4♂); **MEXICO: No Data** (USNM: 2♂, 1♀). **VENEZEULA: Maroni River** (USNM: 1♂, 1♀). **NO DATA** (USNM: 2♂, 6♀).

Psoloptera thoracica (Walker, 1854)

(Figs. 3, 12, 13, 14)

Euchromia thoracica Walker, 1854. List Lep. Ins. Br. Mus. 1: 243.

Psoloptera thoracica Butler, 1876. J. Linn. Soc. Lond. Zool 12: 369.

Diagnosis. Bright scarlet coloration is restricted to the head and thorax in *P. thoracia* (Fig. 3); in *P. basifulva*, the base of the fore and hind wings are orange-red, as well as the thorax and portions of the head (Fig. 1). *Psoloptera leucosticta* lacks red coloration altogether (Fig. 2).

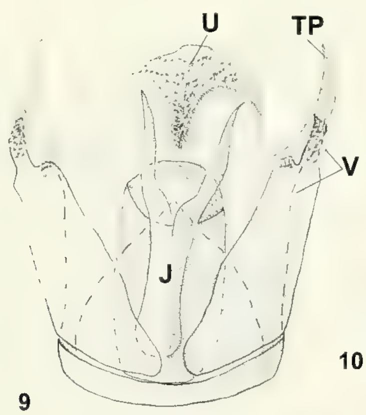
Description. Medium-sized, black moths with red heads and thoraces (Fig. 3).

Male. *Head*. Vertex black with pair of white spots; galae scarlet; antenna black, biserrate and ciliate; palpus black.

Thorax. Patagium scarlet; mesothorax scarlet with scattered, long black scales; metathorax scarlet; fore, mid and hind legs black with white spots on coxae.

Wings. Forewing. Length = 12–17 mm (average = 14.6 mm, SD = 1.3 mm, *n* = 9). Black. Hindwing. Costal region gray, grading to black at CuA_1 and CuA_2.

Abdomen. Pair of white lateral spots present on first abdominal segment; remainder of abdomen black dorsally; medial white spot



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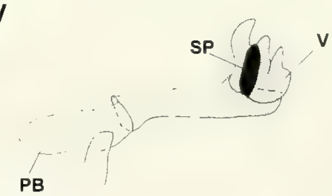

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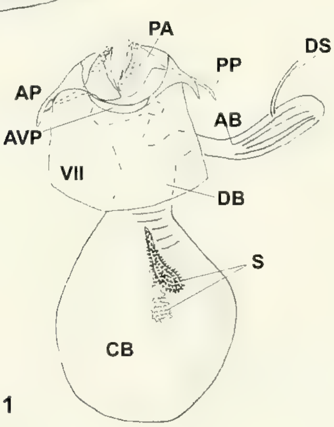

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FIG. 9. *Psoloptera leucosticta* (Hübner), male genitalia, ventral view. J = juxta, TP = tegumenal process, U = uncus, V = valve. **FIG. 10**. *Psoloptera leucosticta* (Hübner), aedagus, lateral view. C = cornuti, PB = phallic base, V = vesica. **FIG. 11**. *Psoloptera leucosticta* (Hübner), female genitalia, ventral view. VII = seventh sternite, AB = accessory bursa, AP = anterior apophysis, AVP = antevagellar plate, CB = corpus bursae, DB = ductus bursae, DS = ductus seminalis, PA = papillae anales, PP = posterior apophysis, S = signa.

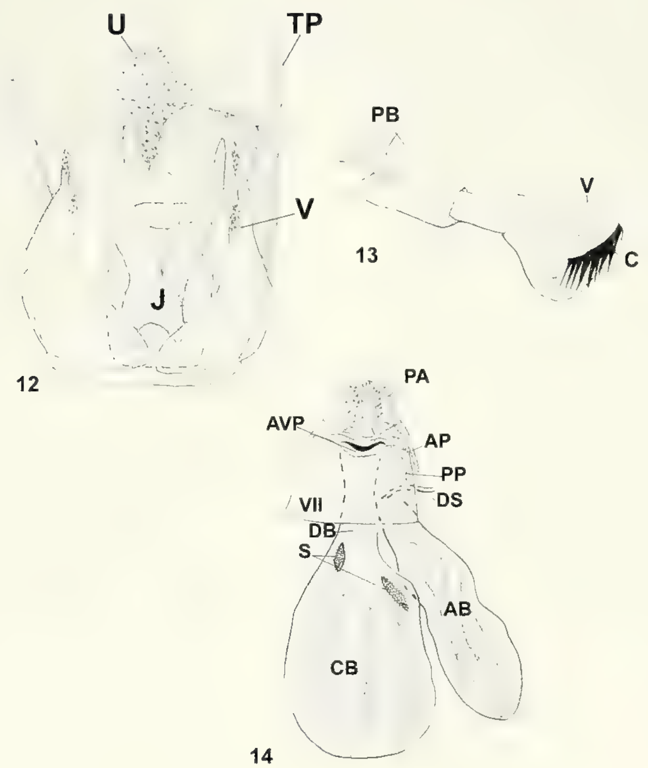

FIG. 12. *Psoloptera thoracia* (Walker), male genitalia, ventral view. J = juxta, TP = tegumenal process, U = uncus, V = valve. **FIG. 13**. *Psoloptera thoracia* (Walker), aedagus, lateral view. C = cornuti, PB = phallic base, SP = sclerotized plate, V = vesica. **FIG. 14**. *Psoloptera thoracia* (Walker), female genitalia, ventral view. VII = seventh sternite, AB = accessory bursa, AP = anterior apophysis, AVP = antevagellar plate, CB = corpus bursae, DB = ductus bursae, DS = ductus seminalis, PA = papillae anales, PP = posterior apophysis, S = signa.

present on venter of first three abdominal segments; remainder black ventrally.

Genitalia (Figs. 12 & 13). Tegumen rounded with elongate spindlelike projection on either side of uncus; uncus strongly hooked, setose; saccus rounded; valve apically narrowed, ending in rounded projections, setose; juxta with butterfly-shaped structure, strongly sclerotized; vesica with sclerotized plate and medial patch of medium-sized cornuti.

Female. As in male, except antennae filiform and ciliate; forewing length = 16 mm (average = 16 mm, SD = 0, n = 2).

Genitalia (Fig. 14). Papillae anales, posterior and anterior apophyses unmodified; sternite 7 unmodified; antevagellar plate with heavily sclerotized lip, symmetrical; ductus bursae membranous; corpus bursae membranous, bearing two patches of signa; accessory bursa large, irregular in shape, from ductus bursae; ductus seminalis from base of accessory bursa.

Type material. The holotype male of *Euchromia thoracia* Walker (BMNH) is labeled: Ega, Bates, 51–43. Type locality: Amazones [Brazil].

Specimens examined. BRAZIL: Amazones: Fonte Boa (BMNH: 5♂, 3♀), Pegas (BMNH: 1♂), Rio Ucayla (BMNH: 2♂), S. de Villa Franca (BMNH: 12♂), S. Paulo (BMNH: 1♀); **Cundinmarca**: Cananche (BMNH: 1♂); **Ega**: (BMNH: 4♂); **Humayta** (BMNH: 5♂, 2♀); **Lower Amazon and R. Madeira** (BMNH: 1♂); **Rio Maderia**: Allianca below S. Antonio (BMNH: 1♂); **San Juan**: Solimoens (BMNH: 1♂); **S. Paulo de Olivenca** (BMNH: 4♂, 5♀; USNM: 4♂); **Sao Paulo de Amazones** (USNM: 2♂, 1♀); Teffe (BMNH: 6♂; USNM: 1♀). **COLOMBIA: Caqueta**: Rio Orteguaza nr. Rio Peneya (USN♂: 1♂, 1♀); **Chiriguana District**: Lake Sapatoza Region (BMNH: 1♂); **Llanos of Rio Meta**: S. Martin (BMNH: 1♂); **Magdalena Valley** (BMNH: 1♀); **Ort.**: Medina (USNM: 1♀); **R. Cantinere**: Muzo (BMNH: 3♀); **Rio Negro** (BMNH: 1♂); **Villaricua** (USNM: 1♀). **COSTA RICA: Guanacaste**: Santa Rosa National Park (BMNH: 1♂, 1♀); **Turrialba** (USNM: 2♂, 1♀). **ECUADOR: Napo Prov.**: Yasuni Research Station, Rios Tivacuno & Tiputini, 76° 36' W, 0° 38' S, 250 m (USNM: 2♀); **Sarayacu** (BMNH: 1♂, 1♀). **GUATEMALA: No Data** (BMNH: 1♀); **PANAMA: Alhajuelo** (USNM: 1♀); **Barro Colorado Island** (USNM: 5♀); **Canal Zone** (USNM: 1♂): Corozal (USNM: 2♂); **Canno Saddle** (USNM: 2♀); **La Chorrera** (BMNH: 2♀); **Matachin** (BMNH: 1♀); **PortoBello** (USNM: 1♂, 2♀); **No Data** (BMNH: 1♂; USNM: 1♂). **PERU: Amazones**: Cavallo-Cocho (BMNH: 2♀); **Pebas**: Loreto (BMNH: 1♀); **Rio Udayali**: Contamama (BMNH: 1♀); **Tarapoto** (BMNH: 1♂); **No Data** (BMNH: 1♂). **VENEZUELA: Aroa** (USNM: 6♂, 5♀); **La Cruces Colon.** (BMNH: 2♀); **Las Quigas**: San Eseban Valley (8♂; 3♀); **Las Quigas nr. San Esteban** (BMNH: 3♂, 2♀); **Palma Sol** (BMNH: 1♂); **San Esteban** (BMNH: 11♂, 3♀); **Valencia** (BMNH: 1♂); **Valera** (USNM: 1♂); **No Data** (BMNH: 2♂, 1♀). **NO DATA**: (BMNH: 1♂; USNM: 1♂, 1♀).

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FOREST TENT CATERPILLAR: MATING, OVIPOSITION, AND ADULT CONGREGATION AT TOWN LIGHTS DURING A NORTHERN MINNESOTA OUTBREAK

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ABSTRACT. Mating and oviposition of the forest tent caterpillar, *Malacosoma disstria* (Hübner) (Lasiocampidae), were studied in two sites ≈2 ha each at levels 1– 5 m above the ground, and adult congregation at lights was studied in brightly lit town districts. The observations were made near or at Ely, St. Louis Co., Minnesota, in the latter years of an outbreak peaking during 1999–2003. Descent of the nomadic larvae from the forest canopy to less defoliated vegetative strata for feeding and cocooning later enabled mating to be observed conveniently from the ground. Adult activity began or intensified at ≈5:30 pm CDT, when males vigorously sought mates in foliage harboring cocoons. Mating pairs were captured and caged in jars containing a host branchlet for oviposition; mean duration of copulation was 202 min. Captive mated females always oviposited the morning after mating; mean duration of oviposition was 88 min. Dispersal behavior always preceded oviposition. Five new oviposition hosts were recorded. Naturally deposited egg rings were found most often on branchlets oriented nearer horizontal than vertical. Females congregating in brightly lit districts were usually gravid, but seldom oviposited.

Additional key words: *Malacosoma disstria*, Lasiocampidae, defoliation.

In northern Minnesota and elsewhere, the forest tent caterpillar, *Malacosoma disstria* (Hübner) (Lasiocampidae), builds up periodically to outbreak densities (Witter 1979). During Minnesota outbreaks, quaking aspen, *Populus tremuloides* Michx. (Salicaceae), and most other broad-leaved trees and shrubs except red maple, *Acer rubrum* L. (Aceraceae), are severely defoliated. Red maple contains an antifeedant (Nicol *et al*. 1997), but the nomadic larvae readily spin cocoons among its leaves. The forest tent caterpillar is univoltine, and the larvae hatch in spring at host bud-break (Batzer and Morris 1971).

Many thousands of hectares of forest, primarily quaking aspen, were defoliated in the outbreak that peaked during 1999–2003 in northern Minnesota when this study was done (Minnesota Dept. of Nat. Res. For. Ins. Disease Newsletter 1999–2004). Although defoliation seldom kills trees, it reduces their wood-volume growth, and the larvae are considered a nuisance by landowners and outdoor recreationists (Duncan *et al*. 1956). The eastern tent caterpillar, *Malacosoma americanum* (Fabricius), also occurs in Minnesota (Stehr and Cook 1968), but mostly in the eastern part of the State, and it was not seen in the outbreak area. Fitzgerald (1995) provides an exhaustive compendium of information for all *Malacosoma*.

At low, nonoutbreak densities, forest tent caterpillar adults mate high above the ground in the forest canopy; during outbreaks they mate on lower, understory vegetation. Mating nearer the ground occurs because larvae descend to less defoliated strata to find food and cocooning sites (Batzer *et al*. 1995), and males concentrate their search for mates where female cocoons occur. The larvae require angled surfaces for cocooning, and they commonly create cocoon structures by drawing and spinning leaves together (illustrated by Batzer and Morris 1971 and Fitzgerald 1995, p. 60). In this study, many cocoons were spun on herbaceous plants of the ground stratum as well as shrubs. The downward shifting later enabled mating to be conveniently observed from the ground.

Previous reports touch on topics treated here. Bieman and Witter (1983) described field mating behavior at low and high levels of mate competition, reflecting low and high population densities. Stehr and Cook (1968) noted that forest tent caterpillar oviposition proceeds helically and in a layer one egg deep. Shepherd (1979) reported daily rhythms of male and female activity. Hodson (1941) noted adult congregation at town lights. As elaborated in the discussion section, the present study supplies more or different details about these and related topics.

MATERIALS AND METHODS

This study was conducted near and in the town of Ely, St. Louis Co., Minnesota. Mating and oviposition were observed in two multilayered stands ≈40 yr old. Overstories in these stands were dominated by quaking aspen, but scattered examples of other tree species were present, in descending order of abundance, balsam poplar, *Populus balsamifera* L. (Salicaceae); red pine, *Pinus resinosa* Ait.; jack pine, *P. banksiana* Lamb.; eastern white pine, *P. strobus* L. (Pinaceae); white birch, *Betula papyrifera* Marsh. (Betulaceae); and balsam fir, *Abies balsamea* (L.) Mill. (Pinaceae). The understories were dominated by willow, *Salix* sp. (Salicaceae), but contained scattered examples of other species, in descending order of abundance, red-osier dogwood,

Cornus stolonifera Michx. (Cornaceae); speckled alder, *Alnus rugosa* (Du Roi) Spreng (Betulaceae); pin cherry, *Prunus pennsylvanica* L. (Rosaceae); beaked hazel, *Corylus cornuta* (Marsh.) (Betulaceae); and American cranberrybush, *Viburnum trilobum* Marsh. (Caprifoliaceae). The vertical range of observation was 1–5 m above ground, and the sites were each ≈2 ha.

Copulating pairs captured in late afternoon were caged in wide-mouthed, 1-liter glass jars with gauze-covered tops containing an aspen or willow branchlet 3–6 mm in diameter. Cages were moved in the evening to a darkened basement with temperatures constantly at 17–19°C, which approximated cool, outdoor evening temperatures. Cages were returned in the morning to shaded outdoor spaces where temperatures ranged 19–26°C. Observations of copulation and oviposition durations were made at ≤30-min intervals.

Gender identification of adults was based on antennal rami, which are ≥2× longer in males than in females. Males also are noticeably smaller than females (sample measurements given later). Early in the study, active males were netted and released after their gender was confirmed (n> 20). Females were dissected for verification of their gravid or spent condition. Egg fertility was determined by the presence of embryos.

Egg numbers/ring were estimated as described by Witter and Kulman (1969), and spumaline—the frothy substance that covers egg rings—was removed as these authors recommended by brushing with a discarded toothbrush. Forewings were removed for accurate length measurement. Angles of egg-bearing branchlets in the field were referenced to horizontal and were estimated with a large protractor. All clock hours refer to Central Daylight Time. Statistics were computed with SYSTAT (1992) software, except for G_{adj}, which was computed according to Sokal and Rohlf (1981). The abbreviation SD refers to standard deviation.

Mean daily temperatures during the late larval stage were computed from daily maxima and minima recorded at the Winton meteorological station ≤5 km from Ely (Minnesota State Climatology Office 2005).

RESULTS

Mating. The first adults of the flight season were males, as the species is protandrous. Throughout daily adult activity, starting or intensifying typically ≈5:30 pm, males visible by the hundreds in any directional view flew vigorously and constantly in vegetative strata containing cocoons. They flew mainly in a zone within <0.5 m of tree and shrub canopies, circling, zigzagging, alighting and crawling along branchlets before taking flight again if they did not find an opportunity to copulate. The number of active, searching males around foliage that contained cocoons was ≈4× that around foliage that contained no cocoons. On windy evenings, males confined their activity closer to canopies. During two cool, rainy, late afternoons with ambient temperatures <15° C, only a small fraction of the males known to be present were active.

Many female pupae appeared to emit their calling pheromone (Struble 1970) before they completed eclosion, as up to 6 males often concentrated activity around a single cocoon until the female eclosed. Males copulated with such females within 1–2 sec after the tip of the female abdomen cleared the cocoon. The wings of such females inflated during copulation. Most mating pairs were found within 10 cm of a cocoon structure presumed to be that of the female, and meconium was often seen on such structures. Some copulating females walked several cm as they were being observed before capture, and because of their larger size pulled the smaller males along. None of the females observed in this study attempted to fly during copulation. Females did not always begin calling before completing eclosion. The locations of two such females found resting quietly on cocoon structures were marked for continuing observation during the evening. At first, captured males released within centimeters of these females flew away. However, by onset of darkness both females were in copula, apparently having eventually emitted their calling pheromone. The sexes were always positioned end to end during copulation.

A total of 69 pairs were seen in copula during this study, of which 48 were successfully caged for further observation. Some copulating pairs separated on capture, presumably because copulation had just begun or was nearly completed. Copulating pairs were seen in the field as soon as daily male activity commenced and pairs known to be newly copulating were captured as late as 9:30 pm. Neither active males nor mating pairs were seen during early dawn hours, presumably because of too cool temperatures. Caged pairs remained in copula following capture for 150–255 min, averaging 202 min (n = 10), but it should be noted that beginning and ending of copulation was not always precisely timed, and that some durations are subject to an error of ±30 min. Copulating pairs occurred on all the trees and shrubs named earlier, including the conifers. None of the conifers had been fed on, but they provided cocooning sites under conditions of extensive foodplant defoliation. Based on forewing lengths—a proxy for body size—there was a statistically significant relation between gender body sizes of naturally mating pairs: forewing length averaged 16.8 ± SD 1.42 mm for females, and 12.4 ± SD 1.05 mm for their mates (Pearson's $r = 0.49$, df = 23, $P = 0.013$).

Oviposition. As in other species of *Malacosoma*, the forest tent caterpillar deposits its eggs in one batch during one oviposition event unless disturbed during the process. Of the 48 captive mated pairs, 88% of the females began ovipositing the day after copulation, most starting in early morning. The earliest an oviposition was completed was 7:05 am. Other females began ovipositing later, the latest at noon. If not ovipositing the day after copulation, captive females failed to do so entirely. Duration of individual oviposition in captivity monitored during daily hours of observation, which began at 7:00 am, ranged 65–134 min, averaging 88 min (n = 11). Shorter and longer oviposition durations were associated with smaller and larger egg rings, which imply smaller and larger females and cooler and warmer ambient temperatures.

Just before beginning to oviposit, captive females always exhibited dispersal behavior. For 5–15 min they flew upward and around inside their cages. Further, naturally deposited egg rings were never observed near cocoon structures (n = 74). After attempting to disperse, females became quiet, positioning themselves more or less diagonally on the caged branchlet head up with wings partly spread, and extended abdomenal tips around the branchlet nearly 180° before starting to oviposit. As they oviposited, they gradually moved around and down the branchlet, coating eggs and the egg ring surface with spumaline. The second turn of the egg ring was aligned with the first so that the top margin of rings seldom had gaps (Fig. 1d). By the completion of oviposition, several turns of the egg ring had been deposited and the females were standing on the egg ring surface. Directions of female progression around branchlets during oviposition were clockwise in 12 cases (60%) and counterclockwise in 8 (40%), with only 3 reversals during the process, 2 from clockwise to counterclockwise, and 1 the opposite. Within minutes of completing oviposition females flew vigorously again as before oviposition.

Whether termed 'mass' or 'ring', eggs were deposited as a continuous helical band each turn of which was tightly fitted with the previous turn, the width of the band generally diminishing downward (Fig. 1). When egg ring deposition was observed closely in captivity, seams in the spumaline covering between turns of the band were usually faintly evident as slight depressions, sometimes as ridges. Depending on female size, number of eggs, and branchlet diameter, rings consisted of up to five turns (Fig. 1a, c). After spumaline removal, margins between turns were not evident. After two days of rainy, windy weather, an increase in irregularly deposited eggs was evident in field egg rings presumably because oviposition had been interrupted by such weather (Fig. 1e). Spumaline was more or less clear when dispensed, but darkened after ≈24 h.

For egg rings deposited in captivity, number of eggs/ring averaged 285 ± SD 112 and for those deposited naturally, 246 ± SD 66, and the difference was not significant (Student's t = 1.20, df = 13.8, separate variances, P = 0.25). Based on 5–39 eggs/ring dissected in late July and early August, 94% of rings contained fertile eggs, with an average of 94% of dissected eggs/ring fertile (n = 14). Corresponding values for eggs collected in the field were 100 and 98% (n = 39). These differences between captive and field eggs were close and inferred to be nonsignificant statistically.

Species on which naturally deposited egg rings were found included quaking aspen (76%), willow (12%), with the remainder (12%) on red osier dogwood, balsam poplar, beaked hazel, speckled alder, pin cherry, and American cranberrybush (n = 72).

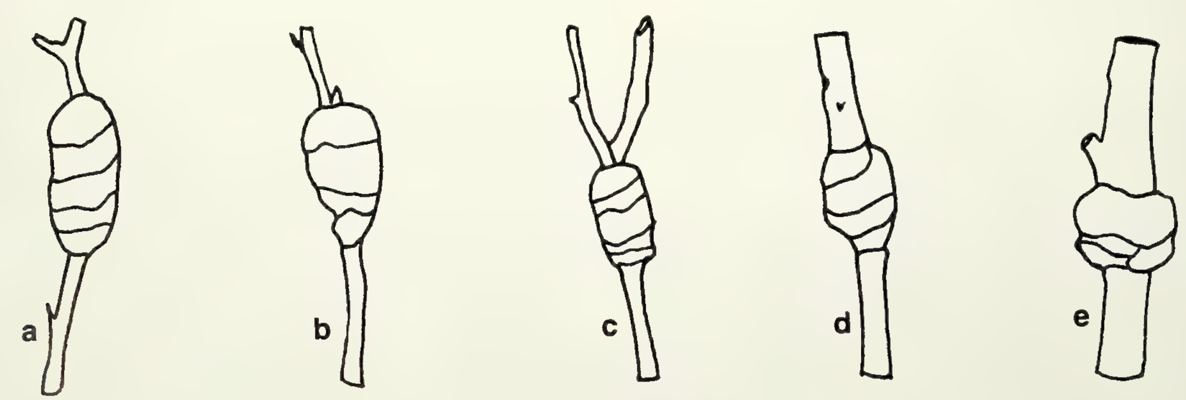

FIG. 1. Delineated margins of the band or bands of eggs in egg rings of the forest tent caterpillar on aspen branchlets. Delineation is based on seams in corresponding spumaline deposition. In the absence of female disturbance, oviposition proceeds in a downward helical manner.

Branchlets on which egg rings were found in the field ranged 2–6 mm in diam. Orientation of egg-bearing branchlets in the field tended to be nearer horizontal than vertical. All 5 samples of 28–74 branchlets containing naturally deposited egg rings in late July and early August were distributed similarly in each sample among three equally progressing angle classes. When pooled, 50% were on branchlets angled 0–30° relative to horizontal, 18% on those 30–60°, and 32% on those 60–90° (n = 291), with departure from a no-preference distribution highly significant ($G_{adj} = 42.9$, df = 2, $P < 0.001$). The distribution through 0–90° thus was backward-J-shaped.

Adult congregation at lights. Like many moths, forest tent caterpillar adults are photopositive. During flight periods, thousands of adults congregated near streetlights and on brightly lit exterior walls of buildings in towns in the outbreak area. In Ely, a few congregated males had frayed wings, indicating much flight history, but the females showed little or no wing wear. The source was almost certainly infested quaking aspen that were ≤1 km distant. Once congregated, the adults remained notably inactive, and seemed to be present night and day until dying or becoming prey of birds and bats. Both genders seemed equally represented, but copulating pairs were seldom seen. Eggs were sometimes seen on building walls, but were scarce relative to the numbers of females present.

Congregated females collected at various times of day for close examination came from the 400–600 and 900 blocks of Sheridan Street in downtown Ely. Their yearly forewing lengths during 2000–2003 averaged 20.0, 18.9, 19.1, and 18.9 mm, respectively, and appeared to indicate temporally decreasing body size ($F = 13.5$, df = 3, 166; $P < 0.001$). Corresponding percentages that were fully gravid were 96, 90, 97 and 58.

DISCUSSION

Mating and oviposition. The present study indicates strongly that the vegetative stratum in which most mating occurs is the one containing the most cocoons. The high frequency with which males were observed to copulate with females at the moment of female eclosion is more likely to occur at high than at low population densities, and was observed earlier in Minnesota (Hodson 1941, Bieman and Witter 1983). Female calling pheromone doubtless stimulated such intense male activity. Bieman and Witter (1983) also reported that some males lingered near empty or parasitized cocoons, as well as brown objects, which suggests they also use visual cues.

Typically, females eclosed and copulated in late afternoon and evening, and oviposited early the next day. The absence of early morning flight activity in this study is not surprising for northern forest tent caterpillar populations. Shepherd (1979) also reported little or no male activity near dawn in Alberta and British Columbia, and found that males ceased flying at <11°C. Such temperatures were common near dawn in the present study. Daily patterns of male activity, female eclosion, and evening female calling closely match those reported by Shepherd.

Shepherd (1979) and Bieman and Witter (1983) also reported attempted dispersal by newly mated captive females. Lack of proximity between naturally deposited egg rings and cocoon structures is further evidence of preoviposition dispersal.

Positive and significant correlation between gender body sizes of mating pairs indicates that the sexes do not mate randomly with respect to size. Reasons for this are unknown, but one might speculate that larger males out-compete smaller ones to mate with larger females. The mean duration of copulation observed in captivity, 202 min, is near the mean duration of 197 min extracted from Table 1 in Bieman and Witter (1983) for their high population density.

Highly variable numbers of eggs/ring averaging 285 in captivity did not seem to differ significantly from the similarly variable mean of 246 observed in the field, nor did the apparent fertility means of 94% in captivity differ significantly from the corresponding 100 and 98% observed in the field. Both higher and lower fertilities were recorded earlier in Minnesota (Witter and Kulman 1972). After close observation confirmed the helical pattern of oviposition reported by Stehr and Cook (1968) and revealed corresponding seams in spumaline deposition, it became possible to reconstruct the course of oviposition in detail (Fig. 1).

Of naturally deposited egg rings found at study sites, 88% were on quaking aspen and willow. The remaining 12% were on 6 lesser utilized oviposition species, of which 5—red-osier dogwood, speckled alder, balsam poplar, beaked hazel, and American cranberrybush—were absent from Fitzgerald's (1995) foodplant tabulation for the forest tent caterpillar and other *Malacosoma*. (Flowering dogwood, *Cornus florida* L., an occasional foodplant of southern populations [Goyer *et al*. 1987], was presumably omitted accidentally from the tabulation.) The new oviposition host records reported here involved no more than 2 egg rings/host, and they are probably explainable by the presence of these plants in areas of high forest tent caterpillar population density.

The backward-J-shaped distribution of angles of branchlets bearing naturally deposited egg rings 1–5 m above the ground is reported here for the first time. Its

significance, if any, is unclear. One possibility is that branchlets nearer horizontal than vertical—where most egg rings were deposited—may be more abundant in midcrowns especially of the overstory and thus provide larvae easier access to the larger foliage volumes at midcrown.

Adult congregation at lights. Hodson (1941) earlier reported adult congregation at town lights where the nearest source infestations were several kilometers distant. In the present study, sources were ≤1 km distant. Such short-range attraction to lights at high population densities does not seem surprising. Female movement to lit areas probably occurred during the evening after late-afternoon eclosion and mating. Most congregated females were gravid, and while their status with respect to mating is unknown, they seem likely to have already mated because of the generally assiduous male pursuit. Congregation results in little reproduction because females do not appear to return to foodplants. The paucity of eggs at lights may result from lack of suitable oviposition sites (branchlets). The decreasing yearly body sizes of congregated females during 2000–2003 may be explainable by either or both of two effects: decreasing diet quality with repeated foodplant defoliation, and the generally inverse relation between body size and direction of temperature difference during late larval development (Miller 2005). During late larval development, 10–19 June, in 2000, when female forewing length was greatest, daily mean temperature averaged a cool 12.4°C, whereas in 2001–2003, when female forewing length decreased, daily mean temperature was higher by an average of 4.4°C. Less common than adult congregation at lights is convective transport of adults in the turbulent air of cold fronts for hundreds of kilometers in a few hours as Brown (1965) reported in Alberta and elsewhere. The population dynamics significance of convective transport is unclear as the gravid and mated statuses of transported females have not been reported.

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A NEW SPECIES OF *EUCOSMA* HÜBNER (TORTRICIDAE: OLETHREUTINAE) FROM THE TALL GRASS PRAIRIE REGION OF MIDWESTERN NORTH AMERICA

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ABSTRACT. *Eucosma haydenae*, new species, is described from Iowa and Illinois. This species, which seems to be a tall grass prairie obligate, is similar in appearance to *E. rusticana* (Kearfott) but is much smaller. A review of *rusticana* is included, and illustrations are provided for the adults and genitalia of both species.

Additional key words: Eucosmini.

The once pervasive tall grass prairie of the North American Midwest is now reduced to a scattered assortment of small disjunct patches, but those remnants still harbor insects that are rarely encountered elsewhere. This paper proposes a name for one such insect, a small brown moth described below as *Eucosma haydenae*, new species. It was discovered during faunal surveys in five prairie preserves, one in northeast Iowa, four in the vicinity of Chicago, Illinois. In general appearance it is most similar to *Eucosma rusticana* Kearfott, but the two species are separated easily by their marked difference in size.

Eucosma rusticana is distributed widely in eastern North America but is rather poorly represented in collections. Kearfott (1905) described the species based on six specimens. Klots (1942) reported two syntypes in the American Museum of Natural History (AMNH), including one labeled LECTOTYPE, a designation he attributed to Heinrich (1923). I examined the lectotype. The second syntype in the AMNH, reported by Kearfott (1905) from Algonquin, Illinois, was not found. I also examined four syntypes at the United States National Museum (USNM).

MATERIALS AND METHODS

This study is based on an examination of 97 adult specimens and 10 genitalia preparations from the following collections: AMNH, Loran D. Gibson, Todd Gilligan (TG), Mississippi Entomological Museum (MEM), USNM, Ron Panzer, and Donald J. Wright (DJW). Forewing length (FWL), defined as distance from base to apex (including fringe), was measured to the nearest one tenth of a millimeter. A rough indication of forewing geometry is provided by the aspect ratio (AR), defined as FWL divided by medial forewing width, the later measurement taken perpendicular to the dorsal margin. Costal fold ratio (CFR) is defined as costal fold length divided by FWL. Reported values of AR and CFR are averages, rounded to two decimal places, of the corresponding values calculated for a small sample of specimens. The number of measurements or observations supporting a particular statement is indicated by n. Forewing pattern terminology follows Brown & Powell (1991) and Baixeras (2002).

SPECIES ACCOUNTS

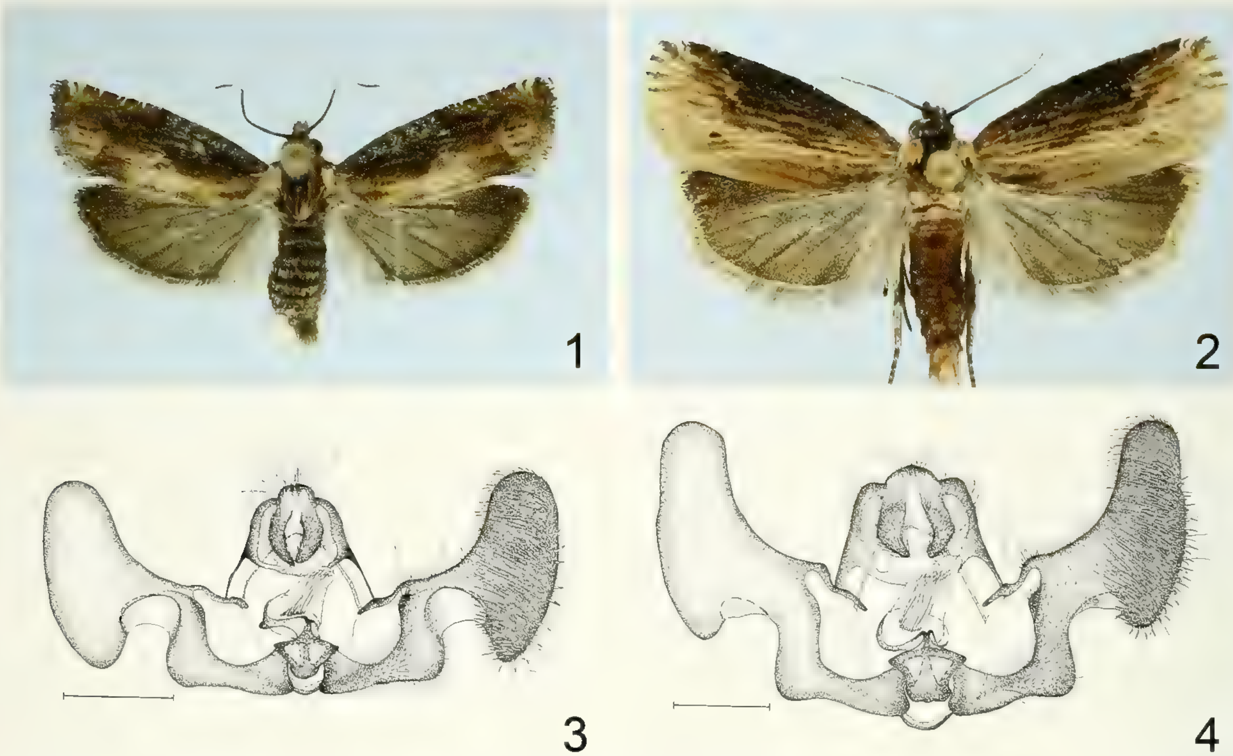
Eucosma rusticana Kearfott
(Figs. 2, 4, 7, 8)

Eucosma rusticana Kearfott 1905:358; Barnes and McDunnough 1917:170; Heinrich 1923:125, Fig. 162; McDunnough 1939:47; Powell 1983:35.

Types. Lectotype designated by Heinrich (1923): ♂, Kerrville, Tex., AMNH. Paralectotypes. NORTH CAROLINA: Tryon, Fiske, 13 May 1903 (1 ♂, USNM), 28 May 1904 (1 ♂, USNM), 1 August 1904 (1 ♂, USNM, genitalia slide 70461), no date (1 ♀, USNM).

Remarks. *Eucosma rusticana* is identified by the following forewing characteristics: dorsal surface (Fig. 2) divided longitudinally into a blackish-brown anterior region and a brownish-tan dorsoterminal region, the line of separation running roughly along the cubital vein from base to ocellus and from there obliquely outward to costa just short of apex; region between said line and dorsal margin crossed longitudinally by three or four brown streaks; ocellus with pale-tan central field, bordered basally and distally by indistinct, transverse, silvery-gray bars and crossed longitudinally by two, variably expressed, dark-brown dashes; ninth costal strigula white and conspicuous, other costal strigulae gray and obscure. In melanic specimens the anterior region of the forewing is nearly all black, with black suffusion extending to dorsum, but the streaked appearance of the dorsal region is still apparent. Forewing statistics: ♂ FWL 9-12 mm (mean = 10.3, n = 25), AR = 2.57, CFR = 0.47,♀ FWL 9.9-12.2 mm (mean = 11.2, n = 5), AR = 2.43.

Male genitalia (Fig. 4) (n = 2): Uncus convex and moderately developed, socii long and setose, dorsolateral shoulders of tegumen well developed, gnathos a narrow band; vesica with ca. 22 deciduous cornuti, valva with dorsal margin strongly concave, apex rounded,



FIGS 1–4: Adults and male genitalia. **1**, *haydenae*, holotype. **2**, *rusticana*, Rowan Co., Kentucky. **3**, *haydenae*, Howard Co., Iowa, slide DJW 556. **4**, *rusticana*, Wyandot Co., Ohio, slide DJW 167. Scale bars = 0.5 mm

ventral two thirds of distal margin convex, dorsal one third mildly inset, producing narrowing of apical one third of cucullus, anal angle rounded, neck with scooped out invagination of ventrolateral margin (indicated by dashed line in Fig. 4), corner of sacculus rounded and nearly right-angled, margin of basal opening with weakly developed medial projection supporting a small patch of spines. **Female genitalia** (Fig. 8) (n = 2): papillae anales small, facing laterally and sparsely setose; sterigma (Fig. 7) semirectangular, length ca. 1.5× width, with shallow trough from center of posterior margin to ostium, lamella antevaginalis ringlike and very weakly sclerotized, lamella postvaginalis with lateral and posterior surfaces densely microtrichiate; posterior margin of sternum VII invaginated to three fourths length of sterigma and closely approximate thereto; ductus bursae short, of nearly uniform width, with variably sclerotized ring posterior to juncture with ductus seminalis; corpus bursae with two, large, fin-shaped signa, inner surface of membrane microtrichiate.

Biology and distribution. I examined 52 specimens (46 ♂, 6♀) from Arkansas, Illinois, Indiana, Kentucky, Missouri, Mississippi, North Carolina, Ohio, Tennessee, Texas and Wisconsin. The flight period extends from mid April to mid August, the earliest records coming from Mississippi. Midwest records are predominantly from June and July. No larval host has been reported, but other members of the genus are known to be stem and root borers of *Asteraceae*.

Eucosma haydenae new species
(Figs. 1, 3, 5, 6)

Diagnosis. Size and forewing maculation distinguish *haydenae* from other eastern North American species of *Eucosma*. Mean FWL of superficially similar *rusticana* is ca. 3 mm longer than that of *haydenae*. Distinctive male genitalic characters include the scooped out invagination of the medioventral surface of the valval neck and the rounded anteroventral projections of the anellus. The sclerotized twist in the female ductus bursae is prominent but not unique to this species.

Description. *Head*: Lower frons creamy white, upper frons creamy white to light brown, vertex brown, scales adjacent to eye lighter; labial palpus with basal segment white, second segment with medial surface and dorsal margin white, lateral surface gray brown with white medial mark, third segment brown, often with blackish-brown apex; antenna with dorsal surface brown, posterior surface white. *Thorax*: Dorsal surface orange brown, scales at posterior extremity of tegula shading to tan, ventral surface creamy white, fore and midlegs with anterior surfaces pale gray brown, posterior surfaces white, hindlegs white to tan, midtibia with white, oblique, medial mark on anterior surface, fore and mid tarsi with pale white annulations. *Forewing* (Fig. 1): ♂ FWL 6–8.2 mm (mean = 7.3, n = 29), AR = 2.82, CFR = 0.48,♀ FWL 7.5–8.2 mm (mean = 7.9, n = 2), AR = 2.71; costa weakly convex, apex nearly right-angled, termen weakly convex; dorsal surface with blackish-brown region bounded anteriorly by basal one half of costa, posteriorly by cubital vein and distally by end of discal cell, region between cubital vein and dorsum white to tan, with orange-brown suffusion near base and along basal margin of ocellus, a narrow, sometimes interrupted, brown streak along dorsal margin; ocellus bordered basally and distally by silvery-gray transverse bars, central field light tan, crossed longitudinally by up to four, variably expressed, thin, black dashes; orange-brown scaling along distal one half of costa, crossed by five, paired, white to gray strigulae and their associated silvery-gray stria; ninth costal strigula white; fringe gray brown anteriorly, becoming paler toward

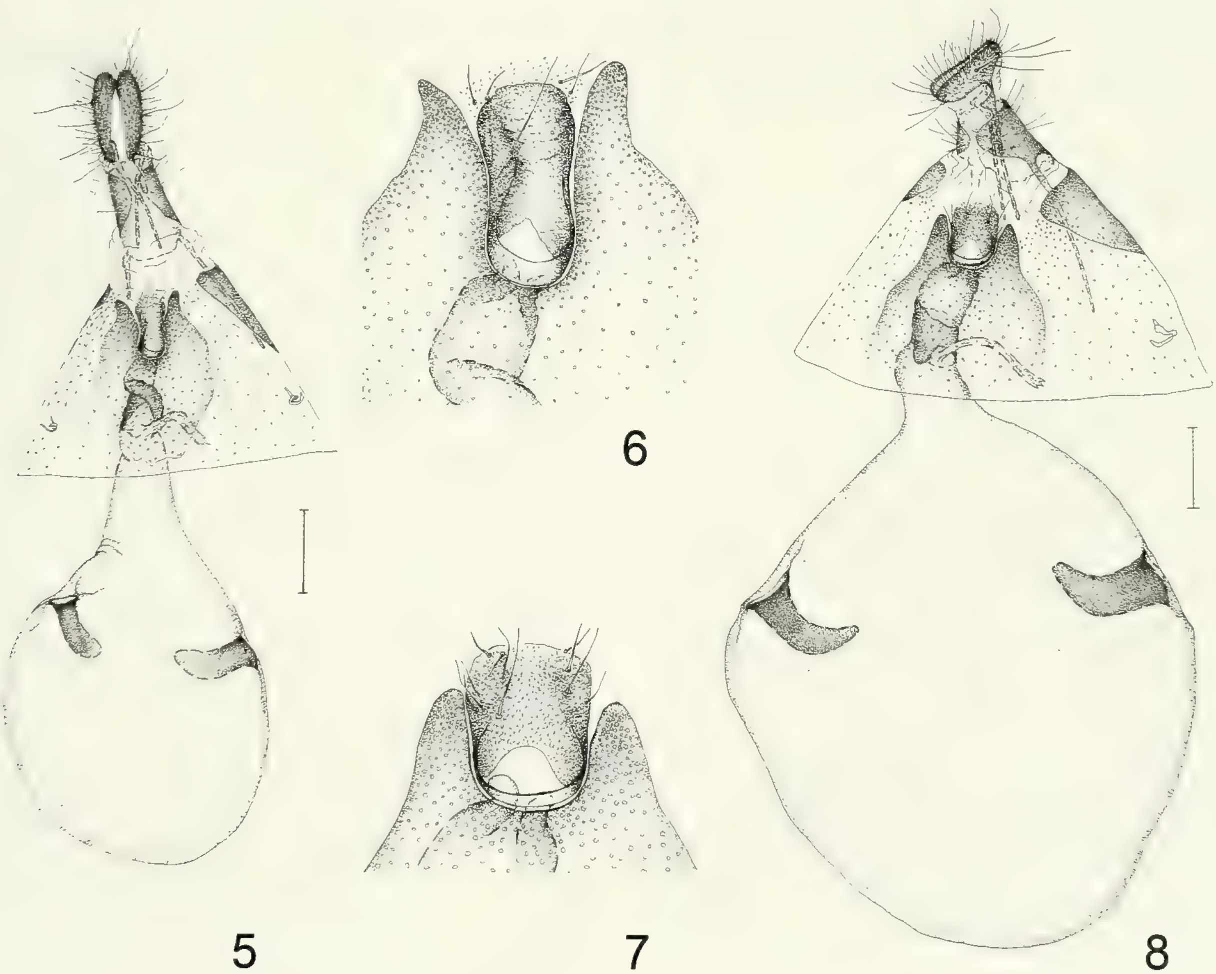
tornus. *Male genitalia* (Fig. 3) (n = 4): Uncus a rounded, dorsally setose lobe, divided medially by shallow indentation; socii long and densely setose; gnathos a narrow band, aedeagus tapered distally, vesica with ca. 22 deciduous cornuti; anellus with small rounded projections at anteroventral extremities; valva with costal margin strongly concave, apex evenly rounded, distal margin convex, ventral angle narrowly rounded, neck with strongly scooped out invagination of medioventral margin, cucullus with medial surface densely setose and with ca. 10 stout setae evenly distributed along distal margin, sacculus moderately setose, margin of basal opening with narrow raised pulvinus, the latter connected to neck by weakly developed ridge. *Female genitalia* (Fig. 5) (n = 2): papillae anales small, facing ventrally and moderately setose; sterigma (Fig. 6) long and semirectangular, length more than 2× width, lamella antevaginalis ringlike and weakly sclerotized, lamella postvaginalis with lateral ridges bordering shallow medial trough, surface microtrichiate; sternum VII with posterior margin deeply and narrowly invaginated to length of sterigma, closely approximate to sterigma; ductus bursae with sclerotized twist posterior to juncture with ductus seminalis; corpus bursae with two fin shaped signa posterior to mid bursa, inner surface microtrichiate.

Holotype. ♂, IOWA, Howard Co., Hayden Prairie, 23 June 1997, D. J. Wright, deposited in USNM. Type locality at 43°26' 35" N, 92°22' 58" W.

Paratypes. ILLINOIS: Dupage Co., W. Chicago Prairie, R. Panzer, 23 May 2004 (5 ♂, 2♀, ♂ genitalia slide DJW1291,♀ genitalia slides DJW1290 & 1296), 6 June 2004 (1 ♂); Lee Co., Green River E., 6 July 2002 (1 ♂). IOWA: Same locality as holotoype, D. J. Wright, 21 June 2000 (1 ♂), 23 June 1997 (8 ♂, genitalia slide DJW 556), 28 June 1995 (2 ♂, genitalia slides DJW 131 & 206), T. Gilligan (2 ♂). Paratype depositories: AMNH, TG, MEM, USNM, DJW.

Etymology. Dr. Ada Hayden (1884–1950) was a botanist at Iowa State College (now Iowa State University) who devoted much of her professional life to the study of the native Iowa prairie (Isely, 1989). Her advocacy in the 1940's for conservation of prairie habitat was largely responsible for the preservation of the 240 acre tract in northeast Iowa that now bears her name and serves as the type locality for the moth described here. It's a pleasure to name this insect after Dr. Hayden.

Distribution and biology. I examined 45 specimens (43 ♂, 2♀), documenting a flight period from late May to



FIGS. 5–8: Female genitalia. **5–6**, *haydenae*, Dupage Co., Illinois, slide DJW 1290. **7–8**, *rusticana*, Cook Co., Illinois, slide DJW 1289. Scale bars = 0.5 mm.

the beginning of July. All were collected in remnant tall grass prairie habitat in Howard County, Iowa, and in Cook, Dupage, and Lee Counties in Illinois. The larval host is not known but, as with *rusticana*, is probably a species of *Asteraceae*.

Remark. The *haydenae* specimens from the Chicago area have a generally blacker appearance than those from Iowa.

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MONARCH (*DANAUS PLEXIPPUS* L. NYMPHALIDAE) MIGRATION, NECTAR RESOURCES AND FIRE REGIMES IN THE OUACHITA MOUNTAINS OF ARKANSAS

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ABSTRACT. Monarchs (*Danaus plexippus*) pass through the Ouachita Mountains in large numbers in September and October on their annual migration to overwintering sites in the Transvolcanic Belt of central Mexico. Monarchs are dependent on nectar resources to fuel their migratory movements. In the Ouachita Mountains of west-central Arkansas migrating monarchs obtain nectar from a variety of plant species, especially *Bidens aristosa* and other composites. Fire suppression has greatly altered the structure of forest communities with major implications for ecological relationships. Sites that are undergoing restoration to a shortleaf pine-bluestem grass community following thinning and frequent prescribed fire, and thought to closely resemble pre-European conditions, support increased abundances of nectar resources and migrating monarchs compared to untreated controls. These results suggest that widespread fire-suppression since the early 1900s has substantially reduced nectar production for migrating monarchs in the Ouachita Mountains Physiographic Region.

Additional key words: Interior Highlands, surveys, restoration

The eastern North American population of the monarch butterfly, *Danaus plexippus* L., undertakes one of the most remarkable migrations of any lepidopteran (Urquhart 1976, Brower & Malcolm 1991). During the fall most individuals of this population migrate to extremely restricted sites in the Transvolcanic Belt of central Mexico (Urquhart 1976, Calvert & Brower 1986). Concern has been expressed about the continued health of this population and the persistence of the massive migration phenomenon (Wells *et al.* 1983, Brower & Malcolm 1991). Changes in abundance and quality of larval hosts (Zalucki & Brower 1992), loss of critical overwintering sites due to logging and fire (Brower 1996, Brower *et al.* 2002), vehicle mortality (McKenna *et al.* 2001), pesticides (Oberhauser 2004), introduced species (Calvert 2004), and transgenic Bt modified crops (Losey *et al.* 1999, Jesse and Obrycki 2004) have been identified as actual or potential threats. Less attention has been directed to landscape-level changes in nectar availability which ultimately fuels the extended fall migration to central Mexico (Garcia & Equihau-Zamora 1997, Brower & Pyle 2004).

Land use changes and management protocols in more natural habitats have drastically altered essentially all the land base that constitutes the breeding range and migration corridors of *D. plexippus* in eastern North America. The Ouachita Mountains Physiographic Region of west-central Arkansas and southeastern Oklahoma, encompassing 3,237,600 ha, remains primarily forested (Bukenhofer and Hedrick 1997). However, logging, fire suppression, and silvicultural management have altered vegetation structure and composition throughout the region (Foti and Glenn 1991, Masters *et al.* 1995). Fire-maintained shortleaf pine (*Pinus echinata*) forests were widespread in the Ouachita Mountains until the early 20th century (Foti & Glenn 1991). Since the original harvest of these pine forests, most forested sites have been altered using intensive short-rotation pine production or remain as more natural forests, but have been subjected to fire suppression for several decades (Bukenhofer and Hedrick 1997). In either case, the abundance and quality of nectar resources available to Lepidoptera has been drastically altered (Thill *et al.* 2004).

The managers of the Ouachita National Forest have initiated a landscape scale restoration of the fire-maintained shortleaf pine-bluestem (*Schizachrium* spp., *Andropogon* spp.) ecosystem on 48,706 ha (U. S. Forest Service 1996). Restoration involves thinning the overstory, reduction of midstory vegetation, and prescribed burning on a three-year return interval. This restoration was undertaken to restore habitat for the endangered red-cockaded woodpecker (*Picoides borealis*) and to restore what is thought to be the pre-European structure and composition of the vegetation (Foti and Glenn 1991, Bukenhofer and Hedrick 1997). A number of authors have examined the effect of these restoration efforts on a diversity of taxa (see Thill *et al.* 2004).

As part of ongoing studies of the effects of restoration of fire-maintained shortleaf pine-bluestem habitat on lepidopteran communities, butterfly and nectar resource surveys were conducted in restored and untreated control plots. This paper reports results for *D. plexippus* in relation to the fire regime and suggests implications for fall migration and over-winter survival.

MATERIALS AND METHODS

This study was conducted on the Poteau Ranger District (34°45'N, 34°15'W) of the Ouachita National

Forest in west-central Arkansas. Topography in this region consists of east-west trending ridges and valleys with an elevational range of 150–820 m. Mixed hardwood forests dominate north-facing slopes and pine and mixed pine-hardwood forests dominate south-facing slopes. Prior to the initiation of fire-suppression activities, much of the landscape, especially the more xeric pine communities on south- and west-facing slopes, burned on a regular basis (Foti and Glenn 1991, Masters *et al.* 1995). These were primarily low intensity ground fires ignited by lightning, Native Americans, and more recently by European colonists. The resulting forest structure was characterized by pine-dominated overstories, sparse midstories, and diverse herbaceous understories (du Pratz 1975, Featherstonhaugh 1844, Nuttall 1980, Foti and Glenn 1991).

The Ouachita Mountains are still predominately forested; however, logging and fire-suppression have dramatically altered vegetation structure (Bukenhofer and Hedrick 1997). Compared to pre-European conditions, existing forests are typically characterized by a younger and denser canopy, a dense woody midstory, and a very suppressed herbaceous understory (Fenwood *et al.* 1984, Masters 1991, Sparks 1996). These changes have profoundly altered the original biodiversity of the Ouachita Mountains (Neal and Montague 1991, Smith and Neal 1991, Wilson *et al.* 1995, Sparks *et al.* 1998, Thill *et al.* 2004).

Landscape scale restoration was initiated in 1979, formally incorporated into the Ouachita National Forest Plan in 1996, and currently projects the restoration of 48,706 ha (7.3% of the Forest) to a shortleaf pine-bluestem condition (U. S. Forest Service 1996, Bukenhofer and Hedrick 1997).

Restoration consists of thinning of the overstory, removal of most midstory vegetation, and prescribed burning on approximately a 3-year rotation (U. S. Forest Service 1996). Ultimately, regeneration of canopy trees will be accomplished primarily through the implementation of irregular shelterwood and seed-tree harvests with a portion of the overstory retained indefinitely (U. S. Forest Service 1996). In addition, rotation age will be lengthened, primarily to provide sufficient older trees to support red-cockaded woodpecker recovery (Rudolph and Conner 1991). At the initiation of our studies, approximately 9,071 ha had been restored in a 42,148 ha landscape on the Poteau Ranger District (W. G. Montague pers. com.). We use "restored" in a relative sense and recognize that stands are on a trajectory toward an ecological state that resembles pre-European conditions.

MATERIALS AND METHODS

We censused butterflies and nectar resources annually in nine restored (treatment) sites and three un-restored (control) sites. Sites varied from 10.5 to 42.1 ha. All treated sites had received a minimum of four prescribed burns prior to the initiation of the study. Restored sites were included as portions of larger areas (range 65 to 2226 ha) burned on the same day. A total of three restored sites were prescribe-burned each spring. Consequently, in any given year, first, second, and third growing seasons post-fire were each represented by three sites. Additional details concerning treatment and control sites can be found in Thill *et al.* (2004).

Adult butterflies (only *D. plexippus* data reported here) were censused using a time-constrained walking census along 500-m triangular transects centrally located within each site (Pollard 1977, Pollard and Yates 1993). Individual transects were censused by slowly walking the length of transects for approximately 20 min. Time involved in counting butterfly aggregations, netting individuals for identification, or waiting for sun or wind conditions to conform to set variables was not included in the 20-min period. During 2000–2003, census counts were conducted four times each year (first week of April, June, August, October). Only October data for *D. plexippus* are reported here. Census counts were replicated three times each month, each replicate conducted by a different observer on different days during the survey week. Individual censuses were conducted between 0900 and 1330 hrs CST when temperatures were between 18–36° C and wind velocity beneath the canopy was not too high to suppress butterfly flight (Beaufort Scale <4). Censusing was further restricted to periods when sunlight was sufficient to cast discernable shadows. The response of butterflies to light, wind, temperature and cloud cover varies seasonally and daily in complex ways. Consequently, observer judgement further constrained censusing to those periods when butterfly activity appeared to be substantial. Additional details concerning treatment and control sites can be found in Thill *et al.* (2004).

In addition to census counts of butterflies, we recorded all observations of nectaring and other feeding activities by butterflies observed during this and other studies in the Ouachita Mountains between 1999 and 2004. Voucher specimens were deposited in the herbarium of Stephen F. Austin State University. Plant nomenclature uses the nomenclature found in Smith (1994).

Nectar resources were quantified by counting flowers

in three 1×100-m plots at each study site. Plots were located parallel to each side of the triangular 500-m butterfly census transect. Within these plots all potential nectar resources were counted each week that butterfly censuses were conducted. For most plant species, individual flowers or composite heads (capitula) were enumerated. Inflorescences, or portions thereof, were counted for a few species with small and/or dense aggregations of flowers (e.g. *Ceanothus americanus*, *Allium* spp., *Solidago* spp., Apiaceae). These enumeration decisions were based on estimating the structure that most closely approximated a separate landing site for a typical butterfly.

TABLE 1. List of nectar plants, inclusive nectaring dates by plant species, and number of nectaring observations for monarchs (*Danaus plexippus*) in the Ouachita Mountains, Arkansas during 1999–2005.

Plant Species	Dates	# Observations
Bidens aristosa	9/7–10/5	1890
Eupatorium serotinum	8/20–10/5	164
Solidago spp.	8/1–10/5	101
Vernonia baldwinii	6/30–10/2	93
Cunila origanoides	9/9–10/2	69
Solidago petiolaris	9/27–10/2	60
Liatris elegans	7/2–10/4	44
Helenium amarum	7/2–10/2	40
Aster spp.	9/8–10/5	39
Aster ericoides	9/27–10/4	28
Aster anomalus	9/27–10/2	22
Senecio obovatus	4/5–4/23	21
Solidago rugosa	10/1–10/5	19
Asclepias tuberosa	5/17–8/2	14
Polygonum pensylvanicum	10/2–10/5	13
Eupatorium spp.	8/20–10/5	10
35 other species		74

RESULTS

In the Ouachita Mountains *D. plexippus* adults were rarely observed in spring and summer. However, during the fall migration in September and October, *D. plexippus* were common to abundant. We obtained a total of 2701 *D. plexippus* nectaring observations from 1999 to 2004. All but 101 of these observations were made during September and October (Table 1). *Danaus plexippus* nectared most frequently on *Bidens aristosa* (1890, 70.0%), *Solidago* spp. (180, 7.0%), *Eupatorium serotinum* (164, 6.1%), *Aster* spp. (98, 3.6%), *Vernonia baldwinii* (93, 3.4%), *Cunila origanoides* (69, 2.6%), *Liatris* spp. (59, 2.2%), and occasionally on an additional 31 species. The 1890 nectaring observations on *Bidens aristosa* were during the fall migration, and were concentrated primarily on the verges of the extensive road system within the region.

Due to low regional abundance we counted only 15 *D. plexippus* during April, June, and August censuses. During October, generally the peak of migration, a total of 1019 *D. plexippus* were detected during transect surveys. These observations occurred most often on restored treatments, especially during the first growing season post-fire, rather than on controls (Table 2). Significant differences were detected across treatments (χ^2 = 1637.6, df = 3, P < 0.001).

Nectar resources were also more abundant on restored treatments than on controls (Table 3). Within restored treatments, nectar resources were more abundant on first year post-burn treatments and least abundant in third year post-burn treatments during the October surveys. Significant differences were frequently detected across these four treatments (Table 3).

TABLE 2. Number of *Danaus plexippus*, summed across plots and observers, detected during October surveys on restored sites and control sites on the Ouachita National Forest during 2000–2002.

Year	B-1[a]	B-2	B-3	Control
2000	55	29	53	9
2001	746	101	13	0
2002	8	3	1	1
Total	809	133	67	10

[a] B-1, B-2, and B-3 correspond to 1st, 2nd, and 3rd growing seasons post-burn.

DISCUSSION

Restored sites in the Ouachita Mountains consisting of a fire-maintained shortleaf pine-bluestem community supported a higher abundance of *D. plexippus* during migration than un-restored, fire-suppressed controls. This pattern was most noticeable during the first October post-fire. Both aspects of this pattern were similar to the abundance of nectar sources. Numbers of *D. plexippus* detected varied considerably across years. This may have been due to timing of the migration relative to our survey times, or changes in *D. plexippus* numbers in the eastern North American

TABLE 3. Response of nectar resources to pine-bluestem restoration on the Ouachita National Forest during October 2000–2002. Mean number of nectar resources per 300 m^2 plots in restored and control stands. Means in the same row sharing the same letter were not significantly different in a 1-way ANOVA with REGWQ at $P < 0.1$ (SAS Inst. Inc. 1988:598). Because abundance values varied greatly within treatments, data were rank transformed prior to analysis.

	B-1[a]		**B-2**		**B-3**		**Control**		
Year	**x**	**SE**	**x**	**SE**	**x**	**SE**	**x**	**SE**	***P***
2000	746.3A	66.4	84.3B	45.9	59.3B	21.9	7.3C	5.0	0.0010
2001	2745.0A	604.9	3219.0A	1605.5	515.3B	106.2	183.7B	130.4	0.0047
2002	4587.3A	2987.2	1746.7A	689.1	719.3AB	355.0	35.0B	8.3	0.0181

[a] B-1, B-2, and B-3 correspond to 1st, 2nd, and 3rd growing seasons post-burn

population. The very low numbers in 2002 followed catastrophic winter storm mortality at the Mexican overwintering sites the previous January (Brower *et al.* 2004).

In the absence of frequent fire, nectar resources in the forested portions of the Ouachita Mountains Physiographic Region are generally low. Improved pastures and intensively managed pine plantations 2–3 years after planting, the only other significant land uses in the region, also typically support a low abundance of nectar resources. Limited areas of increased nectar abundance occur in disturbed sites, i.e. road verges, utility rights-of-way, fence rows, and areas of recent timber harvest. Thus, at the regional level, in this primarily forested area, nectar resources may be limiting for lepidopteran species that require them (Thill *et al.* 2004, Rudolph *et al.* In prep.). Similar results were found for fire-maintained pine communities in eastern Texas (Rudolph and Ely 2000).

Due to the very patchy distribution of nectar sources in relation to roads, rights-of-way, and forest management we were unable to assess the relative abundance of nectar sources across the entire landscape. The relative numbers of nectaring observations in Table 1 are probably biased toward those occurring along road verges. However, butterflies, including *D. plexippus*, were frequently observed nectaring along the transect surveys, especially in the restored treatments.

Data presented here indicate that fire suppression has resulted in a landscape that is currently depauperate in nectar availability. We suggest that reduced nectar availability, compared to probable pre-European conditions, limits use of the widespread fire-suppressed habitats by monarchs and other lepidopteran species (Thill *et al.* 2004). The large numbers of monarchs passing through the Ouachita Mountains each fall obtain nectar resources primarily from concentrations of flowers located in disturbed sites, mainly the abundant *Bidens aristosa* growing on road verges. How this current availability of nectar resources compares with the pattern of nectar resources dispersed across the forest landscape in the pre-European fire-maintained shortleaf pine forests is unknown, but this pattern suggests that fire suppression has greatly limited the availability of nectar resources across most of the forested landscape.

Lipid-loading by *D. plexippus* during the fall migration, both to fuel the migration and sustain winter survival, is crucial (Brower 1985, Alonso-Mejia *et al.* 1997). Brower and Pyle (2004) suggest that lack of nectar resources might be a limiting factor for migrating *D. plexippus*. In addition, a significant proportion of the monarchs inhabiting the wintering sites in the Transvolcanic Belt lack sufficient lipids to survive until spring (Brower & Pyle 2004). A detailed understanding of the current quality and availability of nectar resources along the migration corridor, and effects of historical changes, would allow an improved understanding of the remarkable migration of *D. plexippus*. Our results suggest that historical changes have been substantial, even in a landscape still dominated by "natural" plant communities. These changes may have potential consequences for migrating monarchs. Habitat and critical ecological processes, fire in this instance, may both be important in maintaining a major biological phenomenon on a continental scale.

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OBSERVATIONS OF *KRICOGONIA LYSIDE* (PIERIDAE) IN THE FLORIDA KEYS

Additional key words: West Indies, migration, seasonal dispersal, Florida Keys

Kricogonia lyside (Godart), (Fig. 1) a butterfly native to the West Indies, the southwestern United States, and Central and South America, has historically occurred on an irregular basis on several of the middle and upper Florida Keys, as well as on the southeastern Florida peninsula (Young 1938, Minno and Emmel 1993, Smith *et al.* 1994, Glassberg *et al.* 2000, Minno *et al.* 2005). A highly migratory species, *K. lyside* often travels *en masse* within and between the islands of the Caribbean

FIG 1. *Kricogonia lyside* on Vaca Key, 23 July 2005 (Photo Credit: H. L. Salvato).

(Wolcott 1927, Williams 1930, Smith *et al.* 1994, Miyata 2000). The species also demonstrates similar mass movements in the southwestern United States with large influxes entering southern Texas from Mexico (Clench 1965, Gilbert 1985). Dispersal of *K. lyside* into and within southern Texas appears to be triggered by reductions in new hostplant growth (Gilbert 1985). However, whether or not similar ecological cues encourage *K. lyside* migrations, both within the Caribbean and to southern Florida, remains unknown. Luis R. Hernandez (pers. comm.) suggests tropical storm activity in the Caribbean may play a large role in the dispersal of *K. lyside* within the West Indies, and perhaps to southern Florida. Smith *et. al.* (1994) witnessed several *K. lyside* making landfall on Upper Matecumbe Key via strong, although not storm-related, easterly winds, indicating the species is capable of dispersal into the Keys during typical seasonal conditions. Young (1938), based on examination of fresh specimens collected near Biscayne Bay, suggested that the species reproduces within southern Florida and the Keys. However, neither oviposition nor larval activity has ever been observed for *K. lyside* in the region. A known hostplant of this species, lignum vitae, *Guaiacum sanctum* L., (Zygophyllaceae) occurs commonly within hardwood hammocks throughout the Keys and is also widely used in the region as an ornamental species in landscaping.

Following an apparent decade-long absence in Florida *K. lyside* was observed locally from June through September 2002 on Plantation Key (Salvato and Salvato 2002) and Key West (MHS unpublished data) in the Florida Keys. After these initial observations of *K. lyside* re-occurrence in the Keys MHS and HLS continued to survey for this species as part of a larger ongoing long-term study to determine the status and distribution of butterflies throughout the Keys. Surveys were conducted on warm, clear days under conditions that were considered sufficient for butterflies to be flying. Each sampling date included approximately 8–9 hours of field time (between 0800–1700 h) in which two surveyors (MHS and HLS) walked a standard route at survey sites within the study area to visually record *K. lyside* activity. On each sampling date a selected span of the Keys was monitored in either the Upper (Key Largo to Upper Matecumbe Key), Middle (Lower Matecumbe Key to Vaca Key) or Lower Keys (Bahia Honda Key to Key West). Survey sites on each island were visited monthly during May 2002 to December 2005, with the exception of Lignumvitae Key, which due to its inaccessibility, was only surveyed during June of each survey year. The amount of time spent surveying for *K. lyside* on each Key varied based on island size and number of survey sites. Overall, a total of 25 survey sites, of varying sizes, were monitored monthly during this study. These locations included State and County parks, National Wildlife Refuges and roadsides. *Guaiacum sanctum* was observed either directly within or adjacent to the majority of our study areas.

Although there were unconfirmed reports of *K. lyside* during 2003, we did not observe the species again in the

Keys until 13 June 2004, after which *K. lyside* was frequently encountered throughout the Florida Keys, as well as southern Miami-Dade County, marking the first known occurrences for the species on mainland Florida in several years. *Kricogonia lyside* was absent from the majority of the islands we surveyed by mid-August 2004; however, local occurrences remained on Bahia Honda within the lower Keys into November of that year.

In 2005, we began to re-encounter *K. lyside* during the early summer months with our first observations occurring on Lignumvitae Key on 11 June. Despite an abundance of *G. sanctum* on Lignumvitae Key, *K. lyside* had never been reported from this island (Minno and Emmel 1993, Smith *et al.* 1994). To our knowledge these observations of *K. lyside* on Lignumvitae Key represent the first reports from this island. From June through August of 2005 *K. lyside* was observed on every island we surveyed within the Keys (Fig. 2). Throughout this time frame the species was witnessed actively dispersing towards the east on both the northern and southern coastlines of the Keys, as well as on outer islands such as Lignumvitae Key, indicating a wider migratory swath than was noted earlier in either the 2002 or 2004 observations. As was observed in 2004, *K. lyside* remained on Bahia Honda until later in the season (at least through 24 September 2005) than elsewhere in the Keys. Table 1 provides an overview of *K. lyside* observations made on various islands within the Florida Keys during this survey. As with Lignumvitae Key, several of the *K. lyside* observations listed in Table 1 appear to be the first documented occurrences of the species on select islands, particularly within the Lower Keys (Minno and Emmel 1993).

We observed an estimated 10, 74 and 238 individuals of *K. lyside* during monthly surveys of the Keys in 2002, 2004 and 2005, respectively. In all years the majority of individuals were found on Key West, Bahia Honda, Vaca Key and Plantation Key with varying numbers of individuals occurring on 15 other islands in the Keys. Although the sexes are similar, males from western Cuba and the Bahamas are distinctive from other known *K. lyside* populations in that these individuals generally lack a black bar near the apex of the upper hindwing (Riley 1975, Minno and Emmel 1993, Hernandez 2004, J. Y. Miller, pers. comm.). Examination of photographs (n = 25), collected specimens (n = 2) and field observations (n = 322) indicate that the *K. lyside* males encountered during

FIG 2. Islands in the Florida Keys on which *Kricogonia lyside* was observed during the survey period.

TABLE 1. *Kricogonia lyside* observations from the Florida Keys during June through September of 2002, 2004 and 2005.

Island	2002	2004	2005
Key Largo			3
Plantation Key	7	12	10
Upper Matecumbe Key		2	1
Windley Key		1	2
Lignumvitae Key			2
Lower Matecumbe Key		2	1
Grassy Key			1
Long Key		7	3
Vaca Key		3	40
Knights Key			12
West Summerland Key			3
Bahia Honda Key		32*	94
Big Pine Key			28
No Name Key			2
Cudjoe Key			4
Sugarloaf Key			2
Saddlebunch Key		1	6
Stock Island		2	4
Key West	3	12	20

* Indicates observations continued until November

these studies were morphologically similar to the western Cuban and Bahamian populations, suggesting that the seasonal occurrences of *K. lyside* in the Keys and southern Florida observed in this study were likely of West Indian origin.

During June to mid-August of 2004 and 2005 *Kricogonia lyside* was consistently observed in active dispersal, traveling in either an easterly or northeasterly direction between islands in search of, and in frequent interaction with, *G. sanctum*. Conversely, *K. lyside* observed later in the season during 2004 and 2005, specifically those remaining on Bahia Honda, occurred only locally and took nectar from any available sources, not just those in the immediate proximity of the hostplant.

Despite extensive searches throughout the study period for signs that *K. lyside* had reproduced or underwent diapause in southern Florida it was not until 9 July 2006 that MHS, HLS and Dennis J. Olle observed the species mating and ovipositing on the fruit and fresh growth of *G. sanctum* on Stock Island and Key West. Additionally on Key West, *K. lyside* was observed actively ovipositing on the leaves of Maracaibo lignum vitae, *Bulnesia arborea* (Jacq.)Engl., (Zygophyllaceae) a non-native species that occurs as an ornamental in the Keys and was not common in our study areas. To our knowledge these observations of oviposition provided the first accounts of *K. lyside* reproduction in southern Florida. However, *K. lyside* larval activity was not observed during these studies. Larvae of *K. lyside* feed nocturnally (Riley 1975, Hernandez 2004) and early instars are similar in coloration to that of the new *G. sanctum* growth on which they feed (Allen *et al.* 2005). The mature larvae are darker green with white and brown stripes (Minno *et al.* 2005). The cryptic coloration and nocturnal feeding habits of *K. lyside* larvae makes the species difficult to find on the hostplant (Luis R. Hernandez, pers. comm.) and may explain our inability to locate them. Additional studies are needed to better determine the occurrence and natural history of immature *K. lyside* in southern Florida. Furthermore, there were no signs of adult *K. lyside* activity across the Keys by mid-fall of 2002, 2004 and 2005, suggesting the species may disappear from Florida and then sporadically re-colonize, probably from Cuba. The tropical storm seasons in 2004 and, for the Keys particularly 2005, were extremely active. However, the influxes and northeastern movements of *K. lyside* across the Keys and into southeastern Florida preceded any significant storms occurring during these study years.

Our observations indicate that *K. lyside* periodically disperses to a greater array of islands in the Florida Keys than previously noted. We have documented that during some years large numbers of *K. lyside* adults occur in the Keys. Additionally, *K. lyside* appears to breed in southern Florida, but to what extent the species colonizes within the state requires further investigation.

The authors thank Luis R. Hernandez for sharing his field observations and insights on the biology of *K. lyside* in the West Indies. Jacqueline Y. Miller examined and presented the authors with her observations of *K. lyside* specimens within the collection of the McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History, Gainesville, Florida. The authors also extend thanks to Tim Adams, Don Stillwaugh Jr, Lyn and Brooks Atherton, Byrum and Linda Cooper, Dennis J. Olle and David L. Lysinger for sharing their field observations of *K. lyside* during the 2004–05 migrations. We also thank an anonymous reviewer for comments that helped improve the manuscript. Finally, the authors thank Barry Wood for creating and editing Figure 2.

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A PRECAUTIONARY TALE ABOUT RARITY: ON THE LARVA AND LIFE HISTORY OF *LITHOPHANE JOANNIS* (LEPIDOPTERA: NOCTUIDAE)

Additional key words: shelter-forming, *Aesculus flava, Lithophane innominata, Lithophane patefacta*

This note is about rarity, and how species that are regarded as scarce may be anything but, once aspects of their life history are better understood. *Lithophane joannis* Covell and Metzler was not described until 1992. Prior to the authors' distribution of paratypes there were no specimens of *L. joannis* in any major eastern institution, i.e., the Smithsonian, American Museum, and Carnegie Museum. Not William Forbes; nor Jack Franclemont, Doug Ferguson, Michael Pogue, Eric Quinter, or Tim McCabe has collected the moth. Dale Schweitzer wrote his dissertation on the tribe—he has yet to see the moth alive. Despite year-round surveys in Great Smoky Mountains National Park (GSMNP)—and especially over the last five years during which time the Park has been the focus of intensive surveys as part of its "All Taxon Biodiversity Inventory"—the moth escaped detection. Yet *Lithophane joannis* is among the Park's most common lepidopterans in middle elevation cove forests.

On 19 May 2001 I collected two *Lithophane* larvae crawling up the trunk of a small yellow buckeye tree (*Aesculus flava* Ait.) (Hippocastanaceae) while collecting moths at a sheet and mercury light (with Doug Ferguson), above the Chimneys Campground (1000m) in Great Smoky Mountains National Park, Sevier County, Tennessee. The caterpillars looked similar to those of the *innominata* group (e.g., *L. hemina* Grote, *L. patefacta* (Walker), *L. petulca* Grote and *L. innominata* (Small), and others), but different enough to raise doubt. Based on the host association and phenotype, Dale Schweitzer guessed that the larvae were those of *Lithophane joannis*. Return trips to the same pullout along Newfound Gap Road in 2002, 2003, and 2004, yielded additional examples of the *Lithophane*. Typically, only one or two caterpillars were collected each year. Unfortunately, I failed repeatedly to rear examples through to the adult stage-inappropriate foliage was offered or larvae were lost during the obligatory, four-month prepupal diapause common to *Lithophane* and other xylenines. In 2005, while light trapping at the same site above the Chimneys Picnic area, I thoroughly searched the same 4m yellow buckeye tree that had yielded caterpillars in every year previous. Nine *Lithophane* caterpillars were found in 20 minutes of searching (by flashlight). The larvae were feeding, perched on the underside of leaves, or observed walking along the trunk, with the exception of two larvae that were recovered from within leaf shelters. Both of these latter individuals were in the process of molting.

Returning to the same area two days later (20 May, 2005), I happened upon a buckeye tree with numerous leaf shelters. Upon opening the first, I found a last instar *Lithophane*. Searching this same tree I counted more than 20 additional *Lithophane joannis* caterpillars in less than 10 minutes by opening other leaf shelters. Nearly every shelter had a caterpillar and some two (few if any of these were in the process of a molt). No additional

caterpillars were obtained by beating limbs of the same tree over a large queen-sized bed sheet. In late September, a series of *Lithophane joannis* issued from this collection (Fig. 1).

The larva of *Lithophane joannis* is strongly mottled (Fig. 2). There is often a straw to yellow tint where adjacent segments overlap and/or a tan to straw flush to the middorsal and lateral stripes. The white dorsal pinacula (D1 and D2 setae) are edged with black; both dorsal pinacula are often embedded in a diffuse dark patch that is best developed over the eighth abdominal segment. The well-differentiated prothoracic shield is heavily blackened above the subdorsal stripe. Below the lateral stripe the subventer and venter are pale and largely unmarked. The head bears a dark coronal bar, a black spot within the frons (frontal triangle), and a black bar above each antenna. Fully mature last instars are about 4 cm in length. The middle and penultimate instars are lime green, translucent, with a strong, somewhat creamy spiracular stripe and a broken, white middorsal stripe; the body bears numerous minute white spots over the trunk (Fig. 3). In appearance the last instars resemble those of *L. hemina* and *L. innominata* and may not be separable from them, although most individuals will be recognizable by their pale ground color, especially those individuals that have a pale green, yellowish, or steely blue cast. In most instances, larvae of *L. joannis* will be identifiable by their host association (with buckeye).

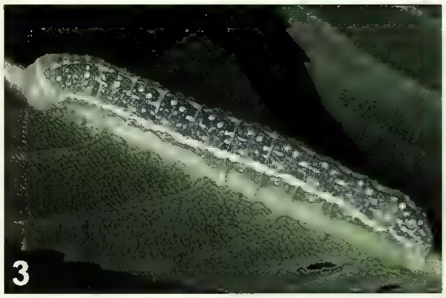
No other eastern *Lithophane* is known to consistently take up residence in leaf shelters. Other members of the *innominata* complex typically rest in bark crevices by day (Wagner 2005) Trunks of *Aesculus flava*—particularly on the understory trees where one can expect to find larvae in numbers—are often smooth and without fissures in which larvae could conceal themselves. It is not clear if *L. joannis* ever spins its own shelters or only uses those of other leps. In May 2006 a collection of 13 additional larvae was made from the Chimneys area of the Park—all came from leaf shelters of microlepidopterans. Eight were collected from abandoned and pupal shelters made by *Choristoneura fractivittana* (Clemens) (Tortricidae) and the remainder from prepupal and pupal shelters spun by *Yponomeuta multipunctella* Clemens[1] (Yponomeutidae).

Several *Lithophane* are known to be both predatory and cannibalistic, including the apparently closely-related *L. patefacta* (Schweitzer 1979; Wagner, 2005). While there would seem to be clear advantages to

[1]While *Yponomeuta multipunctella* larvae normally feed on *Euonymus*, since 2004 I have increasingly noted larvae on other hosts in the Smokies.

1

2



3

FIGS 1–3. *Lithophane joannis*: all from Chimneys area of Great Smoky Mountains National Park, Sevier County, Tennessee. **1**, Reared adult. **2**, *Lithophane joannis* last instar. **3**, Penultimate instar.

having the ability to take over previously spun shelters, cannibalism was not observed in five pint rearing containers that housed 3–5 middle and late instars. And as noted above, I occasionally found shelters with two larvae. Similarly, 10 of 13 larvae collected in 2006 came from occupied microlepidopteran shelters (see above)—no evidence of predation was noted in these (or any of the other shelters opened on the day of the initial collection in the Park).

In the middle elevation cove forests of GSMNP where caterpillars of *Lithophane joannis* were discovered, the insect is among the most abundant noctuid caterpillars—on 20 May, 2005, *L. joannis* was arguably the most common noctuid caterpillar present in the Chimneys area. At the type locality in Ohio, *L. joannis* outnumbered all other members of the genus *Lithophane* at bait (Covell and Metzler 1992). Interestingly, adults ignored the light traps that were run at the same location (Eric Metzler pers. comm.). *L. joannis* provides a noteworthy case of apparent rarity—

if one were to depend on standard light trapping methods one would conclude that the moth is among the rarest lepidopterans in eastern North America. However if one employs bait or searches for caterpillars one could conclude just the opposite, that *L. joannis* is among the most common noctuids in Appalachian forests where its foodplant, *Aesculus flava*, grows in abundance.

Identification of the adults was confirmed by Eric Metzler. Vouchers of both larvae and adults have been deposited at the University of Connecticut; adults have also been deposited at the United States National Museum.

James Adams, Dale Schweitzer, and Bo Sullivan offered suggestions on an earlier draft of the paper and Rene Twarkins assisted with the larval images.

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DIURNAL HERBIVORY DOCUMENTED FOR *SPEYERIA IDALIA* (NYMPHALIDAE) LARVAE ON *VIOLA SAGITTATA* (VIOLACEAE) IN PENNSYLVANIA

Additional key words: regal fritillary, violet, foraging

Only two extant populations of the regal fritillary, *Speyeria idalia* Drury (Nymphalidae), are documented east of Indiana (Barton 1996 for Pennsylvania, Hobson 1999 and Chazal 2002 for Virginia). The larger of the two populations occurs inside National Guard Training Center-Fort Indiantown Gap (NGTC-FIG), an approximately 6,925-ha military base located in south-central Pennsylvania. Comprehensive descriptions of the old-field successional habitats occupied by *S. idalia* at NGTC-FIG are presented in Barton (1996) and TNC (2001). Morphologic and genetic evidence indicates that eastern populations may deserve specific or subspecific status and designation as an evolutionary significant unit (Williams 2001a, 2001b, 2002). In light of the conservation status of *S. idalia*, research is warranted on its life history.

Nocturnal foraging on *Viola* species has been reported or referenced for *S. idalia* larvae by Holland (1898), Ferris & Brown (1981), Opler & Krizek (1984), Schull (1987), Royer (1988), Iftner *et al.* (1992), Royer & Marrone (1992), and West (1998). However, Kopper *et al.* (2001) documented diurnal feeding on *V. pedatifida* G. Don (Violaceae) in three out of 12 *S. idalia* larvae observed in Kansas. At NGTC-FIG, Barton (1995) reported diurnal movements of *S. idalia* larvae and noted the predominance of *V. sagittata* Aiton relative to the presence of other *Viola* species but did not describe larval foraging behavior.

Because *S. idalia* larvae have been challenging to locate in the field across the species' range (Scudder 1889 for New England, TNC 2001 for Pennsylvania, Kopper *et al.* 2001 for Kansas, Debinski pers. com. for Iowa), behavioral observations of larvae have been difficult to obtain (Kopper *et al.* 2001). A combination of factors such as low population density (Barton 1995), small body size, solitary distribution, cryptic coloration and behavior (Stamp & Wilkens 1993), high mortality rates (Mattoon *et al.* 1971, Wagner *et al.* 1997), and concealing vegetation may partially explain the modest numbers of field-documented larvae. Previous surveys conducted at NGTC-FIG to detect larvae have resulted in very small sample sizes (n = 9; Barton 1995) or failure (n = 0; TNC 2000, 2001).

On May 14, 2001, one *S. idalia* larva was unintentionally discovered at the Pennsylvania site during a vegetation study. Shortly thereafter, a qualitative survey of selected grasslands, known to be inhabited by *S. idalia* adults during previous years, was performed in an attempt to detect more larvae. Typically conducted between 0900 and 1600 hrs, the survey followed a generalized protocol: searching for individuals and groups of *V. sagittata* (including arrow- and ovate-leaved varieties), inspecting violets for evidence of strip-feeding herbivory (typical of *S. idalia*), and visually scanning violets and the surrounding area for larvae. Images of *S. idalia* larvae in Allen (1997) and Richard & Heitzman (1987) assisted with positive species identification.

TABLE 1. Spatio-temporal and behavioral data for *S. idalia* larvae observed at NGTC-FIG, Pennsylvania, May 2001. Spatial locations have been normalized by subtracting the coordinate values of the first sighting.

Individual larvae	Date	Time	Spatial location (UTM meters)		Behavior at time of discovery	Diurnal feeding on leaves of *V. sagittata*
			Northing	Easting		
1	5/14	1200	0.0	0.0	motionless; on bare ground°	observed in field
2	5/18	0945	2617.3	5049.6	motionless; < 30 cm from *Viola*	observed in captivity
3	5/18	1102	2618.4	5047.5	motionless; on *Viola*	not observed
4	5/22	1200	361.8	72.5	motionless; on *Viola*	observed in captivity
5	5/24	1110	3557.5	6057.0	feeding on *Viola*	observed in field
6	5/25	1440	2705.6	5041.1	feeding on *Viola*	observed in field

°distance to nearest *Viola* was unrecorded for larva 1

Five additional *S. idalia* larvae were opportunistically discovered after more than 30 observer-hours of search effort (Table 1). Digital photographs were taken of each larva encountered and of the habitat in the immediate vicinity of each sighting. Spatial coordinates of larvae were determined through Global Positioning System (GPS) technology (hardware: Pro XR Trimble receiver unit and TSC1 Asset Surveyor Trimble datalogger; software: Pathfinder Office version 2.80) and expressed in Universal Transverse Mercator (UTM) meters. Larvae were not marked so as to avoid potential handling effects. Because newly and previously identified larvae were indistinguishable, duplication was possible but unlikely, due to the relatively long distances between sightings on preceding days [i.e., ~80 m (minimum), ~7000 m (maximum)]. The two larvae observed simultaneously on May 18 were separated by approximately two meters.

Diurnal foraging on *V. sagittata* was documented in five of the six larvae observed (Table 1 and Figure 1), a strong trend despite the extremely small sample size. Similar to those reported in Kopper *et al.* (2001), feeding bouts were short-lived. *S. idalia* larvae were observed to consume only leaves of *V. sagittata*, either partially or completely. In addition to foliar herbivory, Beattie & Lyons (1975) and Kopper *et al.* (2001) reported floral consumption of *Viola* spp. by the larvae of *Argynnis* spp. and *S. idalia*, respectively. Such behaviors, as well as nocturnal foraging bouts, may have been exhibited by larvae at the NGTC-FIG site but were not observed. Nonetheless, given the observations presented here for Pennsylvania, in conjunction with those for Kansas by Kopper *et al.* (2001), diurnal foraging by *S. idalia* larvae may be more prevalent than

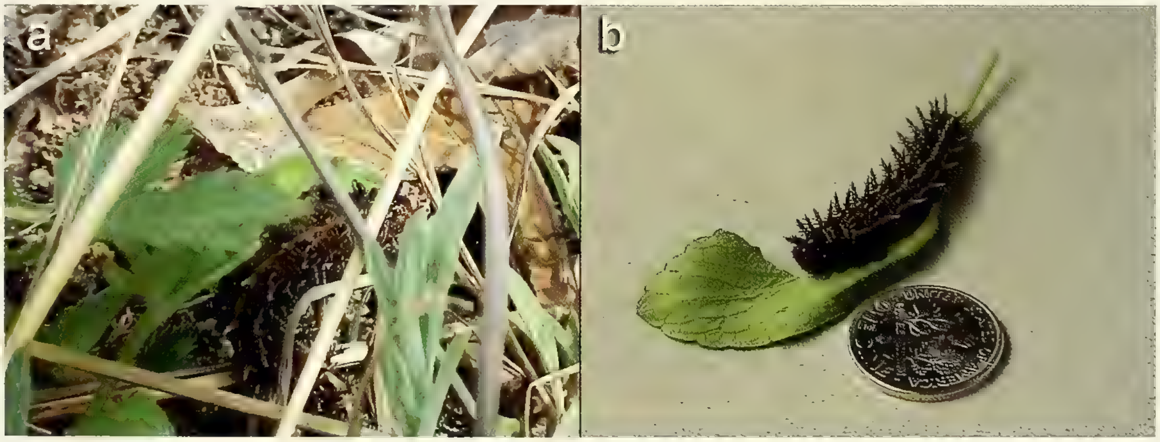

FIG. 1. Images of two *S. idalia* larvae diurnally foraging on *V. sagittata* in the field (**a**) and in controlled conditions (**b**) at NGTC-FIG, Pennsylvania, May 2001.

previously described in the scientific literature.

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THE GEOMETRID MOTHS OF EUROPE (A. Hausmann, ed.), Volume 2. Sterrhinae. Axel Hausmann. 2004. Apollo Books, Stenstrup, Denmark. 600pp. Hardback ISBN 87-88757-37-4. Priced at 140 Euros on http://www.pensoft.net/notes/12090.stm.

This volume represents another significant contribution to a series on European Geometridae that will be seen in retrospect as perhaps the most significant milestone in our understanding of that fauna. Not only does it provide a comprehensive review of our knowledge to date, coupled to an immense amount of fresh research based on exhaustive examination of copious material, but it probably comes at a turning point in the way taxonomic information is presented, with the emphasis moving more towards the electronic media, away from print on paper. The editorial preface indicates the way the volume is embedded within the context of existing or imminent initiatives in electronic informatics for Geometridae. But, as someone who sometimes wonders whether the rush to embrace the electronic age may be more headlong than judicious, given our lack of experience of the security/vulnerability of the internet to all sorts of factors, I am reassured to know that there are hard-copy products such as this to fall back on under any worst case scenario.

The Sterrhinae, after the Larentiinae, are probably the most successful subfamily of the Geometridae in their proportional representation at temperate latitudes, though the Ennominae may have higher numerical representation. They also contain, after *Eupithecia* in the Larentiinae (covered in Vol 4 of this series), the two next most species-rich geometrid genera: *Scopula* and *Idaea*. All three genera pose significant difficulties in identification of their species, so publication of these two volumes has removed this impediment for the European fauna.

The preface notes the strong (particularly western) Mediterranean focus of the subfamily in a European context, relative to the more even distribution of the Larentiinae, but this aspect is not explored to any great extent in the main text, though all the data are there to enable interested readers to analyse it for themselves. For example, there is endemism at a generic level, albeit from genera that are monotypic such as *Anthometra* (eastern Mediterranean) and *Emmiltis* (central Mediterranean), or *Oar*, if regarded as distinct from *Scopula*, with just two species in the Mediterranean. The five species of *Cleta* are also essentially Mediterranean, and also the genus *Glossostrophia*. *Brachyglossina* includes major N. African and Levantine species groups, with one species in Spain considered to be an outlier of the latter group.

Apart from these smaller genera, the Mediterranean focus is seen to an extreme in *Idaea*, where over two-thirds of the species are Mediterranean, 73% of these restricted to the western part. In *Scopula*, as in the larentiine *Eupithecia*, only one third are Mediterranean, and those are more evenly distributed across that region.

The book reviews extensively the recent taxonomic advances made for the subfamily, but there is still not a full consensus on the generic classification, as indicated by Sihvonen (2005, *Nota lepid.*, 28: 70-71) in his review. There is also discussion of relationships of the Sterrhinae within the family as a whole, where there is growing consensus that the Sterrhinae and Larentiinae are the most basal groups, though relationships between the two lineages of Sterrhinae and the Larentiinae still need further study.

All species are copiously illustrated by color plates showing the range of variation, often accompanied by diagnostic half-tone figures in the body of the text. There are clear line-drawings of male and female genitalia, and some stereoscans of critical features of antennae and legs. As with other volumes, the description of the adult is headed as a diagnosis, and the true diagnosis is found as an account of differences of similar species. The text for each species includes extensive reviews of available biological and ecological information, drawing on the breadth of literature and current expertise on the fauna. Most species have larvae that are herbaceous feeders, those of *Idaea* tending to prefer dried or withered foliage. However, the larvae of the genus *Cyclophora* are arboreal defoliators.

The systematic checklist at the end of the book also lists, with asterisks, species from neighboring areas, a particularly useful addition given the Mediterranean nature of the group, enabling the reader to appreciate how the diversity extends to N. Africa, Turkey or the Levant. Species from Madeira and the Canaries are also listed. The distributions of all species are illustrated by maps with shaded areas indicating the general range within which are placed black circles or other symbols indicating more precise localities from which material

has been examined.

The book brings together an immense and diverse amount of information in a clear and cohesive manner that will retain its value for many years to come. It is therefore an investment well worth making.

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